MAY 1958

Journal

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AMERICAN WATER WORKS ASSOCIATION

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Coming Meetings

AWWA SECTIONS

Spring Meetings

May 15–17—Pacific Northwest Section, at Davenport Hotel, Spokane, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., 306 City Hall, Spokane, Wash.

May 15–17—Arizona Section, at El Conquistador Hotel, Tucson. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix.

Jun. 1–4—Canadian Section, at Royal York Hotel, Toronto, Ont. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Commission, Parliament Buildings, Toronto.

Jun. 25–27—Pennsylvania Section, at Hotel Lawrence, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Fall Meetings

Sep. 8–10—Michigan Sec., Grand Rapids.

Sep. 10–12—New York Sec., Lake Placid.

Sep. 15–17—Rocky Mountain Sec., Denver, Colo.

Sep. 17–19—Ohio Sec., Cleveland.

Sep. 17–19—Wisconsin Sec., Wausau.

Sep. 22–24—Kentucky-Tennessee Sec., Memphis, Tenn.

Sep. 24–26—North Central Sec., Duluth, Minn.

Sep. 28–30—Missouri Sec., Jefferson City.

Sep. 28–Oct. 1—Alabama-Mississippi Sec., Biloxi, Miss.

Oct. 15–17—Iowa Sec., Des Moines.

Oct. 19–22—Florida Sec., North Miami Beach.

Oct. 23–24—West Virginia Sec., Charleston.

Oct. 23–25—New Jersey Sec., Atlantic City.

Oct. 28–31—California Sec., Los Angeles.

Oct. 29–31—Chesapeake Sec., Wilmington, Del.

Nov. 5–7—Virginia Sec., Richmond.

Nov. 10–12—North Carolina Sec., Greensboro.

OTHER ORGANIZATIONS

May 12–14—Analysis Instrumentation Div., Instrument Society of America, Shamrock Hilton Hotel, Houston, Tex. For registration information write: H. S. Kindler, ISA Director of Technical Programs, 313—6th Ave., Pittsburgh, Pa.

May 17—Short Course on Conduit Strengths & Trenching Requirements, University College, Washington Univ., St. Louis 5, Mo.

(*Continued on page 8*)

Coming Meetings

(Continued from page 6)

May 18–24—Congress of Inter-American Assn. of Sanitary Engineering (AIDIS), San Juan, P.R. For details, write: Gen. Secy. Enrique Ortega, Apdo. Postal 218, San Juan, P.R.

May 19–23—Short Course on Safety Management Techniques, sponsored by National Safety Council, Chicago, Ill. Write: Director of Industrial Training, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

May 24–31—International Water Supply Congress, Brussels, Belgium (in connection with World's Fair). For information, write: Belgian Organizing Committee, 10 Square Ambiorix, Brussels 4, Belgium.

May 26–30—Water Works School, Dept. of Sanitary Engineering, Univ. of North Carolina, Chapel Hill, N.C.

May 30–Jun. 1—European Organization for Research on Fluorine and Dental Caries Prevention, Brussels, Belgium (in connection with World's Fair). For information write: Dr. M. Joachim, Chairman, Organizing Committee of ORCA Congress, 67 Rue de Treves, Brussels, Belgium.

Jun. 10–12—Appalachian Underground Corrosion Short Course, School of Mines, West Virginia Univ., Morgantown, W.Va.

Jun. 11–14—National Society of Professional Engineers, Chase-Park Plaza Hotels, St. Louis, Mo.

Jun. 22–27—American Society for Testing Materials, Hotel Statler, Boston, Mass.

Sep. 1–13—2nd International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

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IMPORTANT: A full color wall size reprint (20" x 17") of this original painting by Herbert Fillmore is available without obligation to all persons concerned with water planning and supply. Write to W. S. Thomas, Byron Jackson Pumps, Inc., Box 70C, Lawrenceburg, Indiana or ask your nearby BJ Pump office.

Sep. 15–20—International Congress on Large Dams, Statler Hotel, New York, N.Y. For information, write: US Committee on Large Dams, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 5–8—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, Hotel Statler, Boston, Mass. For information, write: Albert H. Hall, Exec. Vice-Pres., NIGP, 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 5–9—Federation of Sewage & Industrial Wastes Assns., Detroit, Mich.

Oct. 13–17—American Society of Civil Engineers, New York, N.Y.

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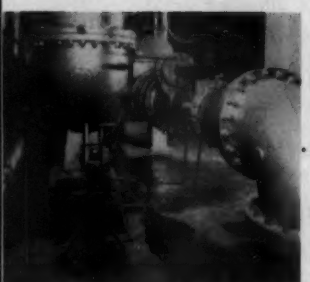

BUILDERS-PROVIDENCE PNEUMATIC MASTER CONTROL SYSTEM and rate-of-flow controllers provide dependable and instantaneous regulation of flows throughout entire system.

CONTROL PANEL in Dallas Pump Station continuously transmits local flows and levels to Wylie . . . from where Synchro-Scan master panel controls Dallas pumps to suit demands . . . further reducing operating costs.

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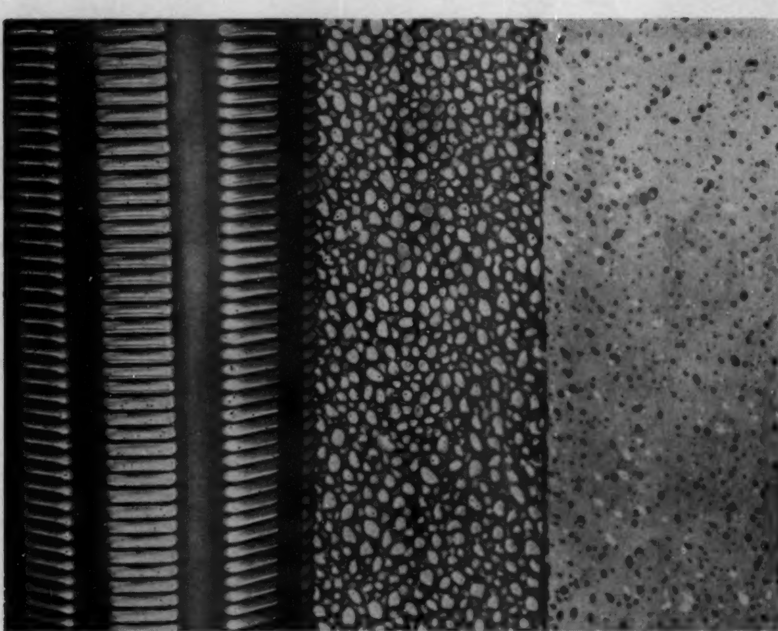

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1978 WATER

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*Here's the proof of flow

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Chicago, Illinois	36"	7,200	2.6-3.6	New	147
New Orleans, La.	12"	29,650	1.2-2.9	New	141
Corder, Mo.	8"	21,350	0.9-2.3	New	143
Univ. of Illinois	8"	400	3.14	New	150
Concord, New Hamp.	14"	500	1.7-2.2	New	151
Concord, New Hamp.	12"	550	2.0-2.4	11	142
West Palm Beach, Fla.	12"	500	2.6-3.4	15	139.5
Greenville, S. C.	20"	87,376	2.4-2.7	12	148.5
Corpus Christi, Tex.	30"	65,641	1.1-1.8	6	146
Summerville, S. C.	8"	500	1.98-2.43	13	142.5
Champaign, Illinois	16"	3,920	3.1-5.6	22	139.3

*Available upon request: Booklet containing flow test and tables on Cast Iron Pipe.

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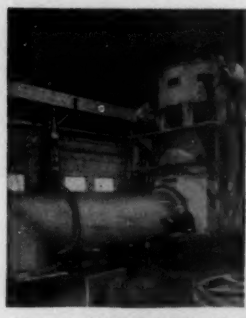
*Based on independent laboratory tests.

pipe FOR MODERN WATER WORKS

Here's why Wheeler-Economy Pumps you buy now



Wheeler's Pump Test Laboratory is one of the largest and best-equipped in the world! Every Wheeler-Economy Pump must pass exhaustive tests here before it's shipped to a customer.

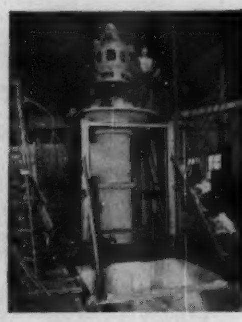
Precision venturi meters and weirs are used to accurately measure pump performance. Typical Circulator shown here pumps 46,000 gallons per minute, weighs 50 tons when filled.

An indoor ocean which holds thousands of gallons of water tests performance of pumps with capacities of from 10 to over 200,000 gallons per minute, and with total heads to 750 ft.

may still be operating efficiently in 1982!

This is one of many Wheeler-Economy Pumps still operating efficiently after 25 years' service—without replacement of major parts! Thorough testing is one of the many good reasons.

A unique part of our facilities is channel model testing—scale-model construction of complete water intake tunnel structures to study all flow characteristics prior to pump sale.



Another advantage Wheeler's Test Laboratory offers is the more rapid development of new pump designs. You can depend on Wheeler-Economy to be first with the newest pumps!

Economy Pump Division

C. H. Wheeler Mfg. Co.

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Centrifugal, Axial and Mixed Flow Pumps • Steam Condensers • Vacuum Equipment • Marine Auxiliary Machinery • Nuclear Products

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 50 • MAY 1958 • NO. 5

Recreational Use of Domestic Water Supply Reservoirs

AWWA Statement of Policy

A statement of policy prepared by the Ad Hoc Committee on Use of Water Storage Resources for Public Recreation, under the chairmanship of Wendell R. LaDue, Chief Engr. & Supt., Bureau of Water Supply, Akron, Ohio. Other members of the committee were: E. Sherman Chase, Lewis S. Finch, C. P. Harnish, Karl F. Hoefle, and Lawson D. Matter. The policy statement was adopted unanimously by the AWWA Board of Directors on Jan. 26, 1958, at its annual meeting, New York, N.Y.

IN the Constitution of the American Water Works Association, the first four objectives of the organization are: [1] to advance the knowledge of the design, construction, operation, and management of water works; [2] to consider and deal with the problems involved in the production and distribution of safe and adequate water supplies; [3] to promote satisfactory relationships with the consuming public; and [4] to give proper consideration to and express opinions upon practices which will enable the industry to render the best possible service to the public.

It will be noted that the second clause relating to the object of the Association obligates members to foster measures designed to provide the public with safe and adequate water. Purveyors of public water supplies have always had the primary responsibility for providing the consumers with safe and palatable water. This traditional objective has a major bearing upon the attitude which the water works executive takes when considering public entry to reservoirs and reservoir lands, which are dedicated to the highest benefit of the people served by the installations.

The factors involved in the protection of water supplies are so varied as to locality, size, and facility that a definite policy attendant to the ownership and control of reservoirs and their marginal areas has not been established by practice. The establishment of a specific overall policy is impracticable. Further, the water works executive must necessarily consider the implications of the varying attitudes of the public toward the utility's prop-

erties. This variation is wide when applied to privately owned and publicly owned properties. He must, however, always bear in mind his primary responsibility to supply a safe and palatable water. Moreover, the location, purpose, and utility of reservoirs must be considered in reaching decisions concerning recreational uses.

Reservoirs may be classified as:

1. *Equalizing reservoirs*—reservoirs within the area served and delivering finished water ready for consumption to the distribution system.

2. *Terminal reservoirs*—areas providing end storage of water prior to treatment.

3. *Upstream reservoirs*—reservoirs providing storage of untreated water at various points in the watershed to provide or supplement the supply at the terminal.

Equalizing and Terminal Reservoirs

Policy: It is considered generally that recreational use of equalizing and terminal reservoirs and the adjacent marginal lands is inimical to the basic function of furnishing a safe and potable water supply to the system's customers, and should be prohibited.

Upstream Reservoirs

Impounded or stored water in upstream reservoirs can be classed in three categories:

Class A: Water derived from an uninhabited or sparsely inhabited area, at or near the point of rainfall or snow melt collected in a storage reservoir, clean and clear enough to be distributed to the consumers with disinfection only.

Policy: Safe practice in the water works field recognizes the necessity of permitting no recreational activity on the water and watershed lands in and about such storage reservoirs.

Class B: Water impounded from an area not heavily inhabited and allowed to flow from storage in a natural stream to the point of withdrawal and requiring treatment in varying degree in addition to disinfection.

Policy: Limited recreational activities on such reservoirs and adjacent lands are considered permissible under appropriate sanitary regulations.

Class C: Water which has flowed in a natural stream before storage for a considerable distance, having received polluting materials from municipalities, industries, or agricultural areas; confined in a reservoir primarily for purposes of storage until such time as low stream flow makes the stored water necessary for the use of the downstream city; and later allowed to flow from the reservoir to the tributary water works in an open stream accessible to the public; and requiring complete treatment.

Policy: Recreation is considered permissible under appropriate sanitary regulations. The determination of the kind and extent of recreational use shall be the sole responsibility of the water works executive of the system involved, whose primary obligation it is to provide a safe and potable water, and subject only to existing police powers.

Summary

The American Water Works Association registers its opposition to legislation permitting or requiring the opening of domestic water supply reservoirs and adjacent lands to recreational use. Control of water supply reservoirs must remain the prerogative of the water purveyor.

Studies of Radioactivity in the Chicago Water Supply

James C. Vaughn, Robert W. Schmidt, Alfred Tenny, and Arthur Shor

A paper presented on Mar. 21, 1958, under the sponsorship of AWWA, at the Engineers Joint Council's Nuclear Engineering and Science Congress, Chicago, Ill., by James C. Vaughn, Asst. Chief Water Chem. Engr., Robert W. Schmidt, Water Chemist, Alfred Tenny, Water Chemist, and Arthur Shor, Water Chemist, all of the South Dist. Filtration Plant, Dept. of Water & Sewers, Chicago, Ill.

DESPITE the apparent success of governmental agencies and industries in controlling the discharge of radioactive wastes to surface water supplies, water producers feel the need of a radioactivity monitoring program for these supplies at the state or municipal level. It is apparent that prevention or control of discharge of radioactive wastes into water supplies is of primary importance. This is especially true considering that there is no method now applicable on a plant scale which assures complete removal of radioactivity, or even removal to below acceptable levels, should the raw water levels exceed the permissible concentration. Were such a method available, many problems would be presented in treating over 450 mgd of water, an amount frequently pumped through the South District Filtration Plant in Chicago.

As long ago as 1950, officials of the Chicago Bureau of Water realized the hazard of potential radioactive pollution of Lake Michigan waters. At that time, a limited monitoring program was started with the aim of obtaining some background data concerning radioactivity levels in the lake. This program has continued to the present time, with some modification and expansion.

Before discussing the monitoring program it might be well to review some data on permissible concentrations of radioisotopes in drinking water. The maximum allowable concentration for mixed fission products for lifetime consumption, is 1×10^{-7} μc/ml. The 10-day emergency acceptable tolerance, again for mixed fission products, is 9×10^{-3} μc/ml. Table 1 shows the maximum permissible average concentration of some common radioisotopes in water for nonoccupational exposure (*1*). Attention is called to the extremely small amounts of these elements considered permissible in waters for domestic use.

The monitoring program in Chicago is divided into three phases: continuous monitoring, regular sampling and counting of raw and treated water, and sampling and counting of precipitation as rainfall or snow.

Continuous Monitoring

Figure 1 shows the continuous monitor in its present stage of development. It consists of two Geiger tubes

with flowing wells, two count rate meters, a high-voltage supply, and two continuous recorders.* Cast-iron cylinders house the end-window Geiger tubes. One of the tubes monitors raw water, the other tube monitors treated water. The water in the wells flows at a rate slow enough to prevent turbulence or the formation of air bubbles. The tube can, therefore, be positioned quite close to the water surface. The impulses are detected by the Geiger tube, relayed to the count rate meter, and recorded continuously. Gamma rays and some weak beta particles are detected with the thin end-window tubes. The lines recorded on the charts comprise a record of background activity.

The housing around each tube consists of a piece of 8-in. cast-iron pipe. It is designed primarily for protection of the tube from physical shock, as well as protection of the water from dust and other contamination.

Prior to use of the end-window tube, a glass-jacketed Geiger tube was used, in which the water passed through a

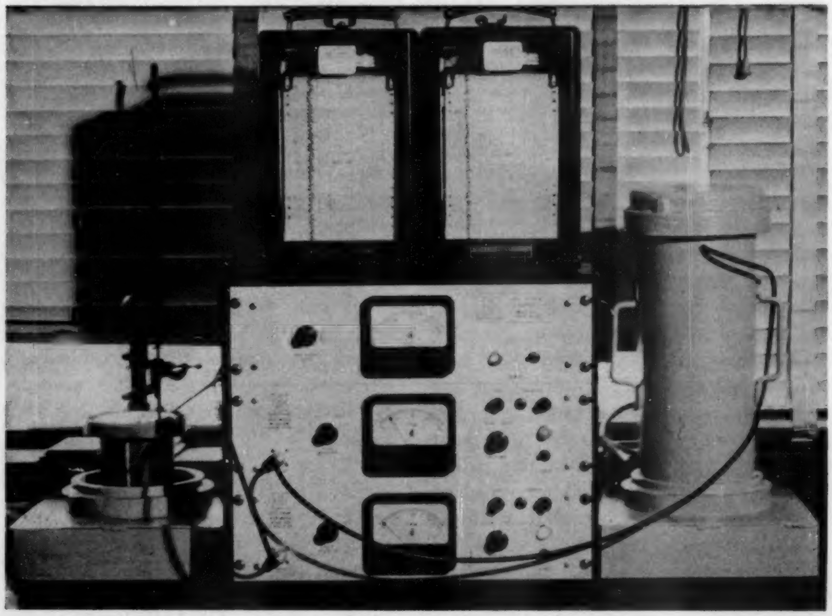

Fig. 1. Continuous Monitoring Equipment

At left and right are end-window Geiger tubes, the right one covered by a cast-iron cylinder housing; the housing is removed from the tube at left to show its position over the continuously flowing well. At the center are the count rate meters, high-voltage supply, and continuous recorders.

* Manufactured by the Esterline-Angus Co., Indianapolis, Ind.

TABLE 1

Maximum Permissible Average Concentrations of Radioisotopes in Water, for Nonoccupational Exposure

Radioisotope	Avg. Concentrations	
	μc/ml	*ppm*
P^{32}	2×10^{-6}	7×10^{-11}
Sr^{89}	7×10^{-6}	3×10^{-10}
Sr^{90} plus Y^{90}	8×10^{-8}	2×10^{-10}
I^{131}	3×10^{-6}	2×10^{-11}
Cs^{137} plus Ba^{137}	1.5×10^{-4}	9.5×10^{-7}
Ce^{144} plus Pr^{144}	3.6×10^{-8}	6×10^{-7}

glass jacket around the tube core. The tube was prone to clog with slime and dirt, and required cleaning at regular intervals. In addition, moisture condensing on the tube caused some short circuiting at the electrical connections. These troubles have been eliminated with the present tube.

The sensitivity of the monitor is of the order of 10^{-4} μc/ml, which enables it to detect radioactivity levels around $\frac{1}{100}$ of emergency tolerance levels. Its greatest value, then, is in giving a continuous record showing whether water from the South District Filtration Plant has or has not approached or exceeded emergency tolerance levels for mixed fission products. It does not record the normal levels of activity in Chicago water, which are about 10^{-8} μc/ml for raw water and 10^{-9} μc/ml for treated water.

Routine Sampling

To measure radioactivity concentrations in the range of levels presented in Table 1, and in the levels normally encountered in surface supplies, a proportional counter is used. As a supplement to the continuous monitoring program, samples of both raw and treated water are collected every 2 hr during each 24-hr period. One sample of each, after proper preparation, is assayed daily in the proportional counter. Samples not used for assay are retained 1 week before discarding.

Preparation of samples primarily involves evaporation of a large volume, to concentrate the activity on a small area, and drying thoroughly. In assaying raw and treated water, a 1-liter sample is acidified, in order to reduce activity adsorption on the glassware surfaces and to prevent precipitation of the dissolved solids. It is then concentrated to about 20 ml by evaporation from a beaker on a hot plate. The remainder is transferred quantitatively to a $2\frac{1}{4}$-in. diameter stainless steel planchet. The planchet is placed beneath infrared heat lamps to evaporate

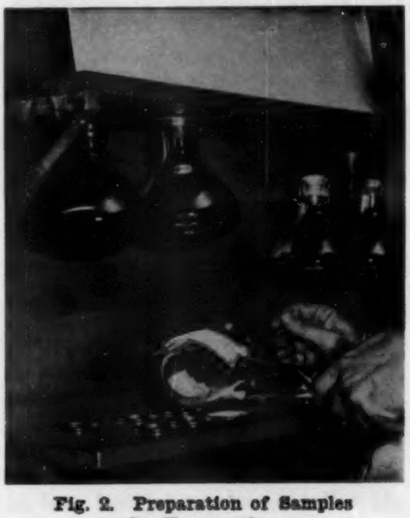

Fig. 2. Preparation of Samples by Evaporation

Water samples are evaporated to concentrate activity in a small area. About 20 ml of water are transferred to stainless steel planchets and placed below the infrared heat lamps for evaporation.

the water. As the planchet holds about 5 ml of liquid, several transfers are necessary. The entire procedure of evaporation, transferring, and drying in an oven for a given set of samples takes about a day. Figure 2 show a sample being prepared.

To correct for self-absorption of the solids in the water, which amount to about 8 mg/sq cm of planchet area, a correction curve has been determined. In obtaining this correction curve, and in daily standardization checks of the counter, a thallium 204 standard was used as a source material. Wheler, Reynolds, and Brooksbank (*2*) have suggested the use of this material, because of its long half-life of 2.7 years, and because its beta energy closely approximates the average of energies occurring in mixed fission products. Use of the correction curve, plotted as counter efficiency versus solids, permits overall corrections for self-absorption, back scattering, and geometry. Such a method of standardization permits comparisons of results on samples from various locations, permits comparison between different laboratories, and gives an accurate basis for measuring changes with time in activity levels in surface supplies.

Radioactivity in Precipitation

The beginning of nuclear weapons tests by the US government during 1952 aroused interest concerning the possibility that radioactive dust and rain would reach the Chicago area. As the Bureau of Water had no dust sample collecting equipment and was in possession of several official government rain gages, it was decided to start a program of precipitation assay. Five widely dispersed pumping stations were selected as sampling points, and since the start of the program, rain or snow samples have been collected after each precipitation of 0.1 in. or more. Only data obtained from the precipitation collected at the South District Filtration Plant is discussed in this article.

The samples are prepared for assay in the internal proportional counter in essentially the same manner as previ-

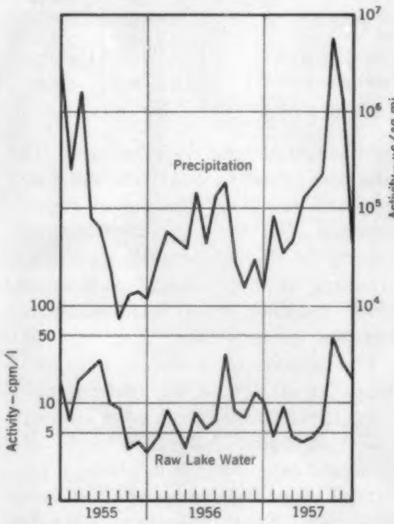

Fig. 3. Radioactivity in Chicago Water

Curves show activity in precipitation and raw Lake Michigan water, as labeled, for the 1955–57 period.

ously described, except that a 200-ml sample has been found to be sufficient.

Figure 3 is a graph comparing integrated monthly precipitation and the average monthly raw-water activity for 1955–1957. These values for the precipitation were obtained by taking the product of activity in microcuries per milliliter for each precipitation and the quantity of precipitation, and then converting to unit areas of 1 sq mi.

The monthly arithmetical averages are used for the raw-water data.

Some correlation between the fallout and the raw-water activity may be noted from Fig. 3. Examples are the peaks reached by both rainfall and raw water in February, May, August, and November 1956 and again in January and July 1957. The July 1957 peak will be discussed in more detail later. The peaks do not always occur in phase, the raw-water peak sometimes occurring a considerable time after the peak rainfall. This is evident in the January 1957 rainfall peak, which precedes the February raw-water peak. It is believed that there are many factors which can affect the concurrence of the peaks and also the quantitative relationship between the rains and raw water. Among others, there may be listed: diffusion in the lake, lake currents, wind direction, drainage into the lake, and water turbidity.

Although continuous data on raw-water and rainfall activities preceding early 1955 are few, there are sufficient data to indicate that the activity recorded in rainfall following the first superbomb in 1954 has never decreased to the level preceding this test. The lake water activity does decrease, however, to prebomb levels during periods of low fallout.

During the summer of 1957 an extensive series of nuclear weapons tests was undertaken by the Atomic Energy Commission. Reference is made particularly to the Jul. 6, 1957, detonation, which was described as one of the largest devices yet tested on United States soil, having a capacity of greater than 60 kilotons. The Diablo test on Jul. 16, and Shasta test on Aug. 19, 1957, were also comparatively high-level detonations. Following the Jul. 6 explosion, a heavy rainfall occurred in the Chicago area, totaling some 4 in. This combination of a powerful bomb detonation followed by an extremely heavy rain produced the highest level of gross activity observed to date in Lake Michigan water. Bomb tests continued throughout the summer, and it was noted that minor peaks occurred in the gross raw-water activity following later rains amounting to more than 1 in. of precipitation.

Figure 4 is a graph showing the variations of gross activity in Lake Michigan water and in treated water during the period from about the middle of June to the middle of September 1957. There is a considerable scatter of plotted points at the lower activity levels, resulting from plant treatment variations and also from statistical fluctuations at these low counting levels. As may be observed in Fig. 4, peaks follow the heavier rains.

The times of bomb detonations are also shown in Fig. 4. These do not appear to have a direct relationship to activity peaks, with the possible exception of the Jul. 6 60-kiloton detonation. Although the rain of Aug. 3 was nearly as heavy, and occurred after four explosions, the peak activity in the water was not nearly as pronounced.

Figure 5 shows in somewhat greater detail the data obtained during the July peak of raw-water activity. It will be noted that on Jul. 13, 1957, one day following the Jul. 12 rain, a very sharp rise in activity occurred. The highest level, however, was not obtained until Jul. 16. That the peak raw- and treated-water activity occurs several days following the heavy rain is an example of the effect which was mentioned earlier. Without specific knowledge of the distribution of rain-

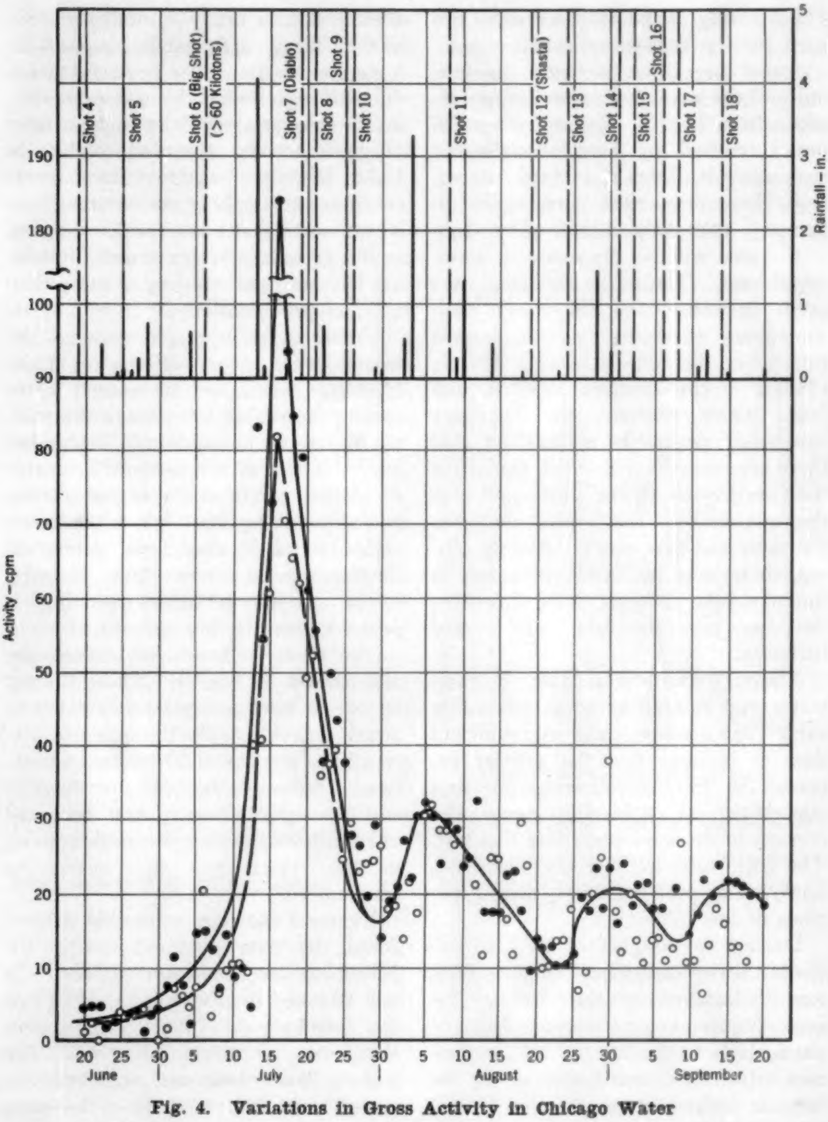

Fig. 4. Variations in Gross Activity in Chicago Water

For the June–September 1957 period, data were plotted to show gross activity for raw water (solid dots and solid curve), as well as finished water (hollow circles and dashed curve). Solid bars at top show rainfall, and dashes at top show dates of AEC tests on nuclear weapons.

fall over the lake, the direction of lake currents, and the vertical circulation in the lake, it is difficult to explain this interesting effect. Prior to Jul. 12, the raw- and finished-water activities show the typical fluctuation of low-level activity in the water. It will be noted that the peak value of 1.35×10^{-7} $\mu c/ml$ for raw water is slightly higher than what is considered to be the lifetime tolerance limit (1×10^{-7} $\mu c/ml$) for potable water containing unknown radioactive contaminants. The value for treated water, however, was less than the maximum permissible at the peak of Jul. 16, 1957. With the normal rate of decay, the raw-water activity did not remain at that high level very long.

Removal of Activity

Very little can be concluded concerning decontamination by the purification plant for low levels. For gross levels of 10^{-8} $\mu c/ml$ and more, however, the removal of activity by plant processes can be measured with what is believed to be reasonable accuracy. This is emphasized by the lines in Fig. 5 showing raw and treated water, both of which move in conjunction during the latter part of July. Figure 6 shows the percentage of removal of radioactivity by the plant, plotted against the raw-water activity for this period. Considerable scatter exists, probably resulting from variations in plant treatment processes based on other considerations in water quality. Nevertheless, it appears that there is a trend between the raw-water gross activity level and decontamination by the plant. An average removal of about 40 per cent was obtained during the July 1957 period, with an observed maximum of more than 70 per cent, and a minimum close to 10 per cent. The dashed line in Fig. 6 represents the percentage of removal of radioactivity by plant processes during the decline in activity following the Jul. 16 peak.

It is interesting to note that for a period of 12 days following the Jul. 16 peak, the activity of the treated and raw water showed a linear decline, so that apparent half-lives of about 5 days and 7 days may be ascribed to the raw and treated waters, respectively. It is recognized that the former decay rate involves not only the natural decay of the radioactive components, but also the effects of convection and diffusion

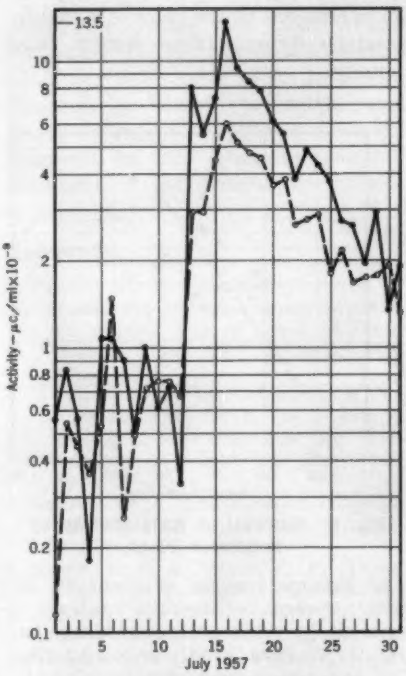

Fig. 5. Gross Activity, July 1957

Solid curve and solid dots represent raw-water activity; dashed curve and hollow circles, finished-water activity.

in the lake, together with the effect of additional rains occurring during the interval. The fact that the finished water shows a somewhat greater half-life than the raw water is, of course, a corollary of the information obtained concerning removal efficiency at different activity levels. In other words, it appears that very short-lived activity is removed by the plant at a slightly greater efficiency than longer lived activity.

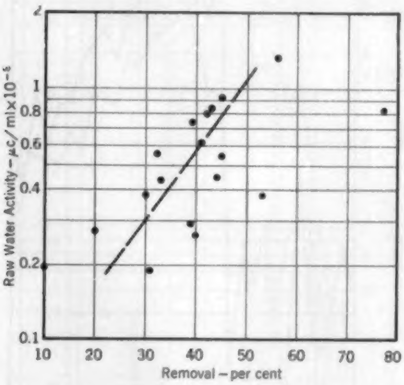

Fig. 6. Removal of Radioactivity by Treatment Plant

The average removal is about 40 per cent. Dashed line indicates efficiency of removal by plant processes during late July 1957, when activity declined following its highest peak.

Strontium and Iodine

During the relatively high activity levels in July, an attempt was made to measure the contributions of strontium and iodine to the gross activity in raw water. The strontium technique used was derived from a combination of the methods of Goldin (*3*), and Hahn and Straub (*4*). After making the usual separation, the number of counts of the yttrium 90 obtained were not statistically significant. It was concluded, therefore, that the strontium 90 was below the detectable limits of the apparatus. This indicated that the amount of strontium 90 even during a period of high gross activity was well below tolerance levels. A number of determinations for iodine 131 were also made. The procedure used was based on that of Glendenin and Metcalf (*5*).

The results of the iodine analyses obtained were ambiguous, because of the comparatively high background of the counting equipment. With a gamma spectrometer of low background at Northwestern University, however, a result was obtained which is believed to be statistically valid. It was shown that the contribution of iodine to the total activity was of the order of magnitude expected for fairly recently produced fission products.

Summary

The South District Filtration Plant has carried out a program of radioactivity monitoring for the detection of contamination of Lake Michigan water more than 6 years. Although this continuous system is not sensitive to the present low activity levels, it serves for the detection of possible sudden and pronounced changes in the activity of the raw-water supply.

In addition, daily samples of raw and finished water are evaporated and counted using a proportional counter to detect changes in radioactivity at levels which are currently encountered. Such measurements have been made over a period of years and are of such sensitivity that increases in the gross activity of the lake following periods

of nuclear weapons testing have been detected. These occurred most frequently during the summer months and coincided with similar peaks in the gross activity in the rainfall. A similar condition was observed during the summer of 1957, when the highest levels occurred that have been measured.

It was possible during July 1957 to measure the removal efficiency of the plant with some accuracy. It was found that an average cleanup of 40 per cent was obtained, and it appeared that the removal of relatively short-lived activities was slightly higher. It was further noted that the activity of the Lake Michigan water declined as a result of natural decay and mixing effects in the lake, with an apparent half-life of about 5 days.

Attempts were made to estimate the activity associated with strontium 90 and iodine 131. No statistically valid results were obtained for the former, but the presence of iodine 131 was indicated. It is expected that further attempts to analyze for strontium 90, using equipment of greater sensitivity and lower background, will be necessary.

Since most water plants lack facilities for radioactivity investigation, it is suggested that if such a program is to be carried out, centrally located laboratories operated by some governmental unit will be required.

Acknowledgments

Appreciation is expressed to Carlos G. Bell, of Northwestern University, for his assistance in certain phases of the strontium and iodine determinations. Appreciation is also expressed to: James W. Jardine, Chicago Commissioner of Water and Sewers; W. W. DeBerard, Deputy Commissioner for Water and Chief Water Engineer; H. H. Gerstein, Assistant Chief Water Engineer; John R. Baylis, Engineer of Water Purification; and Oscar Gullans, Chief Water Chemical Engineer, for their encouragement and assistance in the presentation of this article.

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Chemical Coagulation Studies on Removal of Radioactivity in Waters

Lloyd R. Setter and Helen H. Russell

A paper presented on Mar. 21, 1958, under the sponsorship of AWWA, at the Engineers Joint Council's Nuclear Engineering and Science Congress, Chicago, Ill., by Lloyd R. Setter, Asst. Chief, Radiological Health Program, and Helen H. Russell, Technician, Radiological Health Program, both of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

A RESUME of laboratory studies on the removal of soluble or colloidal radioactivity from water by coagulation, settling, and filtration to simulate conventional American water utility practice was reported by Straub (*1*). Most of these studies were made by adding specific radioisotopes or mixtures of isotopes to synthetic or natural waters prior to coagulation and testing by conventional laboratory methods (*2*). In general, the levels of activity in the test water, measured in terms of microcuries per liter (μc/ml), were estimated at 25,000–15,000,000 $\mu\mu c$/l. This is high compared to the continuous-use maximum permissible level of 100 $\mu\mu c$/l for unidentified mixed activity (*3*). At these levels, observed activity removal in excess of 99 per cent, if attained, would, therefore, be considered unsatisfactory.

Bomb debris consists of mixed fission products and induced activity. It is physically and chemically dissimilar from mixed fission products in acid solution. It can be postulated that changes in its chemical composition and behavior, exclusive of normal decay, occur through the process of weathering and adsorption, before and after deposition on the earth's surface (either as dust or precipitation), where it may become a water contaminant. Reported observations on the removal of this type of water contamination are few (*4–6*), with results indicating a removal of 35–80 per cent of the fallout by coagulation, settling, and filtration.

It is the purpose of this article to summarize the laboratory jar tests on chemical coagulation for the removal of radioactive materials found in Cincinnati rain, cistern water, surface water, and rain leachings through native soils. Included in the study are results of coagulating carbonated and noncarbonated distilled-water extracts of an alkaline soil contaminated with bomb debris.

Methods of Study

In general, the coagulation studies were performed by treating a 1.5-liter sample in a wide-mouth, square-based, pickle jar. A variable speed six-unit laboratory paddle-stirrer was used to provide a 1–2-min rapid mix upon addition of chemical coagulant, followed by a slow 20–30-min flocculation period. A freshly prepared solution of

alum, $Al_2(SO_4)_3 \cdot 8H_2O$, was added to the sample with or without clay, which was added to provide for the adsorption of beta activity or nuclei for floc formation. The pH of the mixed liquor was determined, and the nature of the floc was observed during mixing. Following flocculation, the samples were settled for 30–60 min, with one-half of the sample being decanted and filtered through Whatman No. 42 paper. The filtrate was evaporated to near dryness, and the solids were transferred to dishes for counting (*7*). Where necessary, corrections for self-absorption and decay were made.

After the supernatant was decanted for test purposes, the remaining sample and settled floc in the test jars were alkalinized with lime slurry from freshly slaked CaO. Following rapid and slow mixing for 20–30 min and quiescent settling for 30–60 min, a second decant was removed, filtered, and tested as described earlier for the filtrates of the first coagulation.

Floc formation was observed as being poor (x), fair ($2x$), good ($3x$),

TABLE 1

Results of Coagulations of Low-Activity Rain Samples

Item	Test Number					
	1	2	3	4	5	6
Quality of water						
Total solids—*ppm*	30	30	110	123		13
Dissolved solids—*ppm*	12	12	86	28	72	trace
pH			7.5	8.2		7.4
Age of bomb debris—*days*	14	14	22	14	8	22
Total beta—$\mu\mu c/l$	795	795	801	1,160	4,510	4,530
Dissolved beta—$\mu\mu c/l$	185	185	316	450	910	1,630
Alum coagulation						
Clay added—*ppm*	27	40	38	15		50
Alum added—*ppm*	13	26	19	15	21	25
Lime added—*ppm*					36	
Floc formation	$4x$	$4x$	$4x$	$4x$	$4x$	$4x$
pH	7.2	6.6	7.0	7.3	6.8	6.4
Alkaline coagulation						
Lime added—*ppm*	32			53	33	
Alum added—*ppm*	16			27		
Floc formation	$4x$			$4x$		
pH	5.4			5.3	8.2	
Total beta removal—per cent						
By alum coagulation	80	75	71	73	84	77
By alkaline coagulation	77			71	77	
Dissolved beta removal—per cent						
By alum coagulation	13	(−8)	27	31	20	35
By alkaline coagulation	3			25	(−15)	

or very good (4*x*), with respect to size, apparent density, and, as a consequence, settleability. Occasionally, because of poor floc formation or low pH, additional chemical was added during flocculation to adjust conditions for optimum coagulation at the minimal chemical dose. In other circumstances, particularly with cistern waters, large samples were available so that chemical dose was varied, and other chemicals, such as trisodium phosphate or ferric sulfate, were used to investigate conditions for maximum removal of beta activity.

For soil extracts and some rain, samples of 1 liter or less were used for alum coagulation and, where available, a second liter was used for alkaline-alum coagulation.

Rain, Cistern, and Surface Waters

The results obtained in coagulating twelve Cincinnati rain samples are presented in Tables 1 and 2, and show a variation in total beta activity ranging from 795 to 31,900 $\mu\mu c/l$ of nuclear bomb debris 8–22 days old. Except for a few samples, it may be noted that all of the suspended, and part of the dissolved, beta activity was removed by coagulation. Total removals by alum coagulation below pH 7 appear to be superior to alum coagulation at

TABLE 2

Results of Coagulations of High-Activity Rain Samples

Item	Test Number					
	1	2	3	4	5	6
Quality of water						
Total solids—*ppm*	32	32	18	20	20	65
Dissolved solids—*ppm*	28	28	6	14	14	29
pH	6.8	6.8	6.4	6.3	6.3	6.8
Age of bomb debris—*days*	22	22	12	12	12	12
Total beta—*$\mu\mu c/l$*	3,150	3,150	18,450	31,900	31,900	26,300
Dissolved beta—*$\mu\mu c/l$*	1,300	1,300	8,450	8,500	8,500	9,600
Alum coagulation						
Clay added—*ppm*	27	27	40			40
Alum added—*ppm*	27	40	20	13	20	20
Floc formation	2*x*	2*x*	*x*	3*x*	3*x*	2*x*
pH	5.6	5.2	6.0	5.8	5.5+	5.7
Alkaline coagulation						
Lime added—*ppm*	16	16	27	16	29	27
Floc formation	4*x*	4*x*	2*x*	3*x*	3*x*	3*x*
pH	9.8	8.9	8.6	7.8	8.2	8.7
Total beta removal—per cent						
By alum coagulation	62	72	83	80	80	81
By alkaline coagulation	71	75	86	62	59	83
Dissolved beta removals—per cent						
By alum coagulation	8	33	63	30	31	48
By alkaline coagulation	31	38	69	(−33)	(−40)	55

high pH. This observation appears to show that activity associated with suspended solids is more leachable at the higher pH values, but does not exclude the possibility that coagulation at high pH has effected more complete removal of soluble alkaline earths, such as strontium 89, strontium 90, and barium 140.

Six cistern waters representing settled rain in which particulate matter had had longer contact with water were coagulated, with the results indicated in Tables 3–5. Table 3 shows that ferric sulfate is no more effective as a coagulant than alum. Neither increased concentrations of clay nor carbon significantly alter the overall removal of suspended or dissolved beta activity. Alum-lime-phosphate treatment at high pH (9.2–10.7) was equal to, or slightly better than, alum with either clay or carbon at a coagulation pH of 6.8–8.4.

Analysis of the results given in Table 4 indicates that trisodium phosphate in cistern water coagulated with alum at pH 6.7–7.0 was inferior to ferric sulfate-phosphate coagulation at pH 4.7–9 and alum coagulation at pH 6.6–7.7.

Alum or ferric sulfate plus phosphate plus lime, at pH values 9.2–10.7, was superior to any other combination of chemical coagulants. The total chemical dose, however, was high, varying from 63 to 93 ppm.

The results presented in Table 5 show greater variation in total and dissolved removals. The results of Tests 1–4, on samples low in total and dissolved beta activity, show that the percentage of removal by coagulation is substantially inferior to that on the more radioactive cistern waters.

Seven waters, consisting of Ohio River water, lake water from impoundment of local streams and four Cincinnati rain water leachings through native sandy or clay loam soils, were coagulated. Most of the rain radioactivity had been removed by the natural process of adsorption and sedimentation or percolation, so that the residual dissolved radioactivity represents the most difficult fraction to remove by coagulation. The results, presented in Table 6, show a removal of 30–76 per cent of the total beta and 6–48 per cent of the dissolved beta in all samples except the Ohio River water filtrate. The river water filtrate was more radioactive after coagulation than before.

The results of the rain, cistern, and surface water studies are summarized in Table 7 for an overall comparison of the many pertinent factors contributing to the extreme variability of removals achieved in the laboratory by jar test studies. The average removal of total activity increases from about 50 per cent for surface waters to about 75 per cent for rain water relatively high in suspended activity. Over the range of chemical dosages used, there appears to be little benefit in coagulation at any particular pH value, although the high chemical doses at high pH values often showed a measurable decrease in the removal of dissolved beta activity.

Soil Extracts

A soil, containing 263 μc of 7-month-old nuclear bomb debris per kilogram of dry sample, was separated into six size fractions with standard sieve size No. 8, 20, 40, 70, and 90. Each soil fraction was serially extracted, initially with distilled water and subsequently with carbonated water. From six extractions of each soil size it was determined that 1.1 $\mu c/kg$ soil went into

TABLE 3

*Comparisons of Methods for Coagulations of Cistern Water**

Item	Test Number					
	1	2	3	4	5	6
1a. *Alum coagulation*						
Clay added—*ppm*	13	13	13	40	40	40
Lime added—*ppm*	7	13	13	7	13	13
Alum added—*ppm*	13	20	27	13	20	27
Floc formation	4*x*	3*x*	4*x*	4*x*	4*x*	4*x*
pH	6.9	7.9	8.0	7.9	8.4	8.2
1b. *Concurrent phosphate-lime coagulation*						
Na_3PO_4 added—*ppm*	8	8	8	8	8	8
Lime added—*ppm*	32	32	32	32	32	32
Floc formation	4*x*	3*x*	4*x*	4*x*	3*x*	4*x*
pH	10.6	10.6	10.6	10.6	10.6	10.6
2. *Ferric sulfate coagulation*						
Clay added—*ppm*	13	13	13	27	27	27
$Fe_2(SO_4)_3$ added—*ppm*	13	27	40	13	27	40
Floc formation	4*x*	3*x*	*xx*	4*x*	4*x*	4*x*
pH	6.4	5.0	4.3	6.4	5.7	4.9
3a. *Alum–activated carbon coagulation*						
Carbon added—*ppm*	7	7	7	20	20	20
Lime added *ppm*	7	7	7	7	7	7
Alum added—*ppm*	13	27	40	13	27	40
Floc formation	4*x*	*x*	*xx*	4*x*	4*x*	4*x*
pH	7.1	6.2	6.5	6.8	7.0	6.9
3b. *Concurrent phosphate-lime coagulation*						
Na_3PO_4 added—*ppm*	7	7	7	7	7	7
Lime added—*ppm*	13	13	13	13	13	13
pH	10.3	10.1	10.2	10.6	10.6	10.6
Total beta removal—per cent						
1a. Alum and clay	62	62	65	66	66	70
3a. Alum and carbon	64	64	67	63	67	66
2. Ferric sulfate	62	62	57	62	62	57
1b. PO_4–Lime	63	66	54	72	66	67
3b. PO_4–Lime	62	65	68	64	69	64
Dissolved beta removal—per cent						
1a. Alum and clay	21	21	28	30	30	27
3a. Alum and carbon	24	25	31	22	31	30
2. Ferric sulfate	27	26	10	27	27	19
1b. PO_4–Lime	22	29	4	42	30	32
3b. PO_4–Lime	22	27	32	25	36	24

* Characteristics of water were: total solids, 35 ppm; dissolved solids, 30 ppm; pH, 6.8; 26-day-old bomb debris; total beta activity, 2,460 $\mu\mu c/l$; dissolved beta activity, 1,180 $\mu\mu c/l$.

solution and 15.2 μc/kg was associated with nonsettlable suspended matter in about 25 liters of extractant. The finer sized grains contained a much higher percentage of both soluble and suspended beta activity.

total solids of 100–600 ppm, and pH values of 8.0–9.0 for the coarse to fine soil fractions, respectively.

Portions of 500-ml size from each of these twelve extracts were coagulated with 80–120 ppm of filter alum at pH

TABLE 4

*Coagulations With Colored Cistern Water**

Item	Test Number					
	1	2	3	4	5	6
1. *Alum coagulation*						
Clay added—*ppm*	13	13	13	40	40	40
Lime added—*ppm*	7	13	13	7	13	13
Alum added—*ppm*	13	20	27	13	20	27
Floc formation	3*x*	4*x*	4*x*	4*x*	4*x*	4*x*
pH	6.6	7.6	7.4	6.8	7.7	7.3
2a. *Phosphate–alum or ferric sulfate*						
Na_3PO_4 added—*ppm*	33	33	33	33		
Lime added—*ppm*					13	13
Carbon added—*ppm*	13	7	20	27	13	27
Alum added—*ppm*	13	13	20			
$Fe_2(SO_4)_3$—*ppm*				40	13	40
Floc formation	2*x*	3*x*	4*x*	4*x*	4*x*	4*x*
pH	7.0	6.9	6.7	4.7	9.0	4.9
2b. *Excess lime*						
Lime added—*ppm*	13	13	13	13		13
Floc formation	4*x*	4*x*	4*x*	4*x*		4*x*
pH	10.2	10.7	10.7	9.2		9.8
Total beta removal—per cent						
1. Alum coagulation	65	66	69	66	63	71
2a. PO_4–alum	48	45	60	58	64	60
2b. Excess lime	69	70	72	81		69
Dissolved beta removal—per cent						
1. Alum coagulation	41	43	48	42	38	51
2a. PO_4–alum (iron)	13	8	33	30	40	33
2b. Excess lime	48	49	53	68		49

* Characteristics of the water were: dissolved solids, 33 ppm; total solids, 43 ppm; pH, 6.4; high color; low surface tension; 25 day-old bomb debris; dissolved beta, 1,910 μμc/l; total beta, 3,200 μμc/l.

The first two serial extractions with distilled water produced comparable beta activities, suspended solids, and pH values for a given soil size—that is, total beta activities of 60–450 μμc/ml, values varying from 6.1 to 7.4. The samples were then treated with 40 ppm CaO for the second coagulation step at pH values ranging from 8.9 to 10.4.

The third extraction of the series was made with distilled water and carbon dioxide bubbled into the slurry of soil at intervals to maintain a pH of 6–7 over a 12-day period. The soil slurries were shaken, settled for 30 min, and the supernatants decanted. From these decantates, 500-ml samples were coagulated with 40 ppm alum and, after removing one-half the supernant, with lime in the presence of the alum floc, as described for treatment of the rain and cistern waters.

In the tests on soil extracts, it was assumed that settled extracts would simulate rainout, or fallout, in runoff. Only a small percentage of the soil contamination, however, was suspended or solubilized.

There appeared to be no significant correlation between the chemical dose, the pH of coagulation, or the level of beta activity on the removal of total activity by either alum or alum-lime coagulation. The twelve tests of distilled-water and the six tests of carbonated-water extracts were therefore considered to be on two similar types of samples; test results are summarized in Table 8.

TABLE 5

Alum and Alkaline Coagulations of Cistern Waters

Item	Test Number						
	1	2	3	4	5	6	7
Quality of water							
Total solids—*ppm*	126	126	46	46	41	41	41
Dissolved solids—*ppm*	62	62	41	41	36	36	36
pH	6.4	6.4	6.2	6.2	6.0	6.0	6.0
Age of bomb debris—*days*	74	74	74	74	25	25	25
Total beta—*μμc/l*	500	500	920	920	2,830	2,830	2,830
Dissolved beta—*μμc/l*	120	120	630	630	1,430	1,430	1,430
Alum coagulation							
Clay added—*ppm*					13	13	53
Alum added—*ppm*	20	27	20	27	20	40	20
Lime added—*ppm*						13	
Floc formation	3*x*	3*x*	3*x*	3*x*	2*x*	3*x*	*x*
pH	5.8	5.4	5.2	4.9	5.5	10.7	5.5
Alkaline coagulation							
Lime added—*ppm*	80	16	16	32	16		16
Alum added—*ppm*	16				16	16	16
Floc formation	4*x*	4*x*	4*x*	4*x*	4*x*	3*x*	4*x*
pH	9.7	9.1	9.2	10.2	8.2	10.2	7.8
Total beta removal—per cent							
By alum coagulation	95	76	36	34	60	59	59
By alkaline coagulation	70	81	38	39	71	57	76
Dissolved beta removal—per cent							
By alum coagulation	81	0	6	3	20	20	20
By alkaline coagulation	(−25)	21	10	11	43	15	53

TABLE 6

Coagulations of Surface Waters and Soil Leachings

Item	Test Number 1	2	3	4	5	6	7
*Source of water**	River	Lake	CL	SL	SL	CL	SL
Quality of water							
Total solids—*ppm*	330	244	161		144	153	106
Dissolved solids—*ppm*	210	230	143	400	130	88	94
pH	9.8	9.2	8.0	7.8	7.6	7.7	7.3
Age of bomb debris—*days*	22	22	14	14	14	12	12
Total beta—$\mu\mu c/l$	164	340	322		630	3,770	5,740
Dissolved beta—$\mu\mu c/l$	50	190	290	310	520	1,370	2,460
1. *Alum coagulation*							
Clay added—*ppm*	57	43	27	27	27		27
Alum added—*ppm*	29	21	13	13	13	30	27
Lime added—*ppm*				32			
Floc formation	4x	4x	4x	x	2x	4x	4x
pH	8.6	7.9	7.6	7.0	7.1	6.7	6.6
2a. *Alkaline coagulation*							
Lime added—*ppm*			32	40	32	18	16
Alum added—*ppm*			16		16		
Floc formation			4x	3x	4x	4x	4x
pH			7.2	9.7	6.8	8.3	8.9
2b. *Excess lime coagulation*							
Lime added—*ppm*			40	40	40		
Floc formation			4x	3x	4x		
pH			10.1	9.7	10.1		
Total beta removal—per cent							
1. Alum coagulation	30	48	43		57	65	73
2a. Alkaline coagulation			53		49	72	76
2b. Excess lime			46		56		
Dissolved beta removal—per cent							
1. Alum coagulation	(−130)	8	36		48	6	38
2a. Alkaline coagulation			48	26	38	26	44
2b. Excess lime			40	32	46		

* CL and SL are leachings of Cincinnati rains through 2-in. beds of clay loam and sandy soil, respectively.

A second set of coagulation tests on soil extracts was made when the bomb debris was 9 months old. At this time, the extracts from each soil size fraction of a serial extraction were combined to provide a stock suspension. Extracts No. 1–6 and No. 8 were serial distilled-water extracts of 2 days or more, except No. 3, which was a 30–45-min wash, performed to separate the fine particles which grew into each soil size fraction. Extract No. 7 was made with distilled water and carbon dioxide, as previously described.

Liter samples of the stock suspensions were coagulated for 30 min with

alum at pH 4.5–7.4, and separate liter samples were alkalinized with lime to pH 10.0–11.1 for 20 min before they were coagulated with alum for 30 min. Clay (apatite) was added to some of the extracts. Seven of the filtrates were tested for strontium 90 to determine preferential removals of this isotope.

The results of these tests are presented in Table 9. The first six serial extractions with water show a progressive decrease in the dissolved beta activity, whereas the total beta activity fluctuated, depending primarily on the suspended matter separated by decantation. The carbonic-acid extract No. 7 had about three times as much dissolved beta activity and dissolved solids as the distilled-water extracts.

When the extracts were coagulated with 40–80 ppm alum at near neutral pH, the removal of total activity varied from 72.6 to 98.9 per cent, depending in part on the amount of suspended beta activity. These values are comparable to the results shown in Table 8. Assuming that all of the

TABLE 7

Summary of Coagulations of Rain, Cistern Water, and Surface Waters

Table No.	Total Solids *ppm*	Type of Sample	Dissolved Beta Range *μμc/l*	Chemical Range* *ppm*	pH Range	Percentage of Removals: Total Beta Range	Total Beta Avg	Dissolved Beta Range	Dissolved Beta Avg
1	41–151	rain	185–1,630	13–57	6.4– 7.3	71–84	76.7	0–35	20
				61–87	5.3– 5.4	71–77	74	3–25	14
				90	8.2	84			(−15)
2	24–94	rain	1,300–9,600	13–40	5.2– 6.0	62–83	76.3	8–63	35.5
				29–56	7.8– 9.8	62–86	72.7	(−40)–69	20.0
3	65	cistern	1,180	20–40	6.9– 8.4	62–70	65.2	21–30	26.2
				20–47	6.2– 7.0	63–67	65.1	22–31	27.2
				13–40†	4.3– 5.7	57–62	60.3	10–27	22.7
				52–72‡	10.6–10.6	54–72	64.7	4–42	27.4
				40–67	10.1–10.6	62–69	65.3	22–36	27.7
4	43	cistern	1,910	20–40	6.6– 7.7	65–71	67.5	38–51	43.8
				46–53‡	6.7– 7.0	45–60	51	8–33	18.0
				26–60†	4.9– 9.0	58–64	60.7	30–40	34.3
				59–66	10.2–10.7	69–72	70.3	48–53	50
				53–73	9.2– 9.8	69–81	75.0	49–68	58.5
5	77–188	cistern	120–1,430	20–27	4.9– 5.5	34–95	60	0–81	21.4
				36–100	8.2–10.2	38–81	61.5	neg–53	18
6	200–474	surface waters	50–2,460	63–45	6.6– 8.6	30–73	53	neg–48	22
				43–85	7.2– 9.7	49–76	57	26–44	37.5
				101–125	9.7–10.1	46	46	32–46	39.3

* Lime and trisodium phosphate and alum or $Fe_2(SO_4)_3$, except as indicated.
† $Fe_2(SO_4)_3$.
‡ Trisodium phosphate, lime, and alum.

suspended activities were readily removed by coagulation, it was calculated that alum coagulation at pH 6.9–7.4 removed 24.6–49 per cent, with an average of 36.6 per cent of the dissolved activity. The removal of dissolved activity in extract No. 4 by alum coagulation at pH 4.5 was 74.3 per cent. The extract contained only 14 ppm of suspended solids, so the floc from 80 ppm alum was largely $Al(OH)_3$.

The strontium 90 content of the filtrate of alum coagulated samples was determined on tests No. 1, 4, 7, and 8, and varied from 140 to 1,190 $\mu\mu c/l$, as compared with the longtime use of strontium 90 maximum permissible concentration value of 800 $\mu\mu c/l$ (*3*). The strontium 90 activity in the filtrate varied from 11.6 to 15.1 per cent.

Lime-alum coagulation consisted of adding lime slurry and mixing for 20 min, to allow chemical interaction with soluble elements, before dosing with alum and coagulating for 30 min. The filtrate activity for all but the carbonic-acid extract was comparable to the filtrates from alum coagulation, with observed removals of all of the suspended and 17.6–60 per cent, or an average of 38.4 per cent, of the dissolved activity.

The carbonic-acid extract, No. 7, chemically precipitated with 224 ppm of lime (CaO), produced far better activity removal, namely, all of the suspended and 81.9 per cent of the dissolved. Even with this high degree of removal, the filtrate had 2,200 $\mu\mu c/l$ of beta activity, of which 7.3 per cent, or 100 $\mu\mu c/l$, was strontium 90.

TABLE 8

Chemical Coagulation of Soil Extracts

Item	Distilled Water*		Carbonated Water†	
	Range	Avg	Range	Avg
Extract analysis				
Beta activity—*μμc/ml*	54.6–484	227	72.7–243	136.1
Dissolved solids—*ppm*			370–680	480
Total solids—*ppm*	100–780	414	630–1,160	840
pH	8.0–9.0		6.4–6.5	
Alum coagulation‡				
Alum added—*ppm*	80–120	92	40–40	40
pH	6.1–7.4		6.4–6.6	
Decant beta—*μμc/ml*	3.2–60	23.1		
Filtrate beta—*μμc/ml*	2.6–51.5	20	11.8–73	35
Beta removal—*per cent*	70–97	91.2	70–84	74.3
Alum plus lime coagulation‡				
Lime added—*ppm*	40–40	40	400–620	510
Alum added—*ppm*			80–80	80
pH	8.9–10.4		8.4–10.6	
Filtrate beta—*μμc/ml*	6.6–80	33.9	5.7–25	13.7
Beta removal—*per cent*	56–94	85	88–92	90

* Twelve extracts.
† Six extracts.
‡ For 30 min.

Comparing the strontium 90 in the lime-alum filtrates to that in the alum filtrates, it is noted that lime-alum filtrates contain one-half to one-fifth the strontium 90 found in the alum filtrates.

dose would cancel each other. The data for these correlations, presented in Table 10, were arranged in three pH ranges of 4–7, 7–9, and 9–11, for the four types of water coagulated. Considering median and average values, the

TABLE 9

Coagulations of Soil Extracts

Item	Extract Number						
	1	2	3	4	5–6	8	7
Analysis of extract							
Suspended solids—*ppm*	550	310	2,000	14	110	185	170
Dissolved solids—*ppm*	410	290	200	150	150	260	460
pH	8.0	8.1	7.6	6.8	8.0	8.0	7.8
Beta activity—*$\mu\mu c$/ml*							
Total	177.4	141.8	351	9.89	19.5	24.9	40.7
Dissolved	15.4	11.85	6.12	3.62	4.22	9.0	12.1
Alum coagulation							
Alum added—*ppm*	40	40	80	80	40	40	40
pH	7.0	7.4	7.0	4.5	6.9	7.1	6.8
Filtrate beta—*$\mu\mu c$/ml*	10.25	7.7	4.0	0.93	2.15	6.8	6.88
Beta removal—*per cent*							
Total	94.2	94.6	98.9	90.6	89.0	72.6	83.1
Dissolved*	33.5	35.0	34.6	74.3	49.0	24.6	43.2
Sr^{90}—*$\mu\mu c$/ml*	1.19			0.14		0.99	1.0
Sr^{90} in filtrate—*per cent*	11.6			15.1		14.5	14.5
Lime-alum coagulation							
Clay added—*ppm*		40	40			40	
Lime (CaO)—*ppm*	56	56	56	45	56	56	224
pH	10.6	10.0	11.1	10.3	10.7	10.5	10.7
Alum—*ppm*	40	60	40	40	20	60	
pH	9.5	7.6	9.9	9.6	10.6	9.5	10.7
Filtrate beta—*$\mu\mu c$/ml*	12.7	7.3	3.6	1.44	2.94	5.2	2.2
Beta removal—*per cent*							
Total	92.8	94.9	99.0	85.4	85.0	79.1	94.6
Dissolved*	17.6	38.5	41.1	60.2	30.4	42.4	81.9
Sr^{90}—*$\mu\mu c$/ml*	0.27					0.54	0.16
Sr^{90} in filtrate—*per cent*	2.1					10.4	7.3

* Assuming 100 per cent removal of suspended activity.

Correlation with pH

An attempt was made to correlate the percentage of removal of total and of dissolved beta activity with the pH of coagulation, assuming that other variables of water quality and coagulant

differences in the removal of total beta are quite insignificant for the three pH ranges. A somewhat greater percentage of total beta removal was obtained with the soil extracts samples (7–9-month-old material of high activity)

TABLE 10

Correlation of Coagulation Results With pH

Sample	Coagulation pH		
	4–7	7–9	9–11
	Total Beta Removal—*per cent*		
Soil extracts*			
Range	83–91	73–99	79–99
Median	89	95	90
Avg	87	91	89
Rain water†			
Range	62–84	59–86	
Median	77	77	
Avg	77	74	
Cistern water‡			
Range	34–95	48–76	30–76
Median	62	62	62
Avg	62	66	65
Surface water§			
Range	49–73	30–76	46–56
Median		53	
Avg	62	54	51
	Dissolved Beta Removal—*per cent*		
Soil extracts*			
Range	43–74	25–38	18–82
Median	49	35	42
Avg	55	33	46
Rain water†			
Range	(−8)–63	(−40)–69	
Median	30	27	
Avg	26	16	
Cistern water‡			
Range	0–81	13–48	(−25)–49
Median	26	30	27
Avg	25	34	29
Surface water§			
Range	6–38	(−130)–48	26–46
Median		36	
Avg	27	35	36

* Number of coagulation tests were: for pH 4–7, three; pH 7–9, five; and pH 9–11, six.
† Number of coagulation tests were: for pH 4–7, eleven; pH 7–9, nine; and pH 9–11, none.
‡ Number of coagulation tests were: for pH 4–7, 23; pH 7–9, fourteen; and pH 9–11, 23.
§ Number of coagulation tests were: for pH 4–7, three; pH 7–9, 25; and pH 9–11, four.

with removals on the order of 90 per cent, as compared to 75 per cent for rain water, 65 per cent for cistern water, and 50–60 per cent for surface water and soil leachings. The percentage of removal of dissolved beta is very variable. All of the suspended activity and 25–35 per cent of the dissolved activity is removed from rain, cistern, or surface water samples. For activity in soil extracts at levels of 10,000 to 350,000 $\mu\mu c/l$ total beta and 4,000–15,000 $\mu\mu c/l$ of dissolved beta, coagulation removed on the average all of the suspended and 35–55 per cent of the dissolved activity.

Summary

Over a 3-year period, radioactive rain, cistern, and surface waters collected in the Cincinnati area have been coagulated with alum, hydrated lime, and coagulant aids in various combinations and pH values for the removal of fallout activity. Water extracts of a soil contaminated with nuclear bomb debris was similarly coagulated. The laboratory jar tests with chemicals and dosages used in conventional water treatment practice indicate that all of the suspended beta activity and part of the soluble beta activity is removed. The longer the activity has been subjected to natural purification (adsorption on surfaces, sedimentation, or percolation), the more difficult it is to remove the remaining soluble activity by coagulation.

Coagulation with lime and alum at about pH 10 favors the removal of alkaline earth isotopes, such as strontium 90.

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Factors Affecting the Transport of Radioactivity by Water

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THE past decade has witnessed a phenomenal growth in the production and use of radioactive materials. From all indications, this growth will continue at an accelerated rate and, as is often the case, this will be accompanied by additional responsibilities and problems. The greatest responsibility faced by the producers and users of radioactive materials is the safeguarding of public health, and many of their most difficult problems will be encountered in meeting this responsibility. The question which must be answered is: What will happen to any radioactive substances released to the environment as a result of our operations and how will they affect mankind?

This question is very complex and the answer depends upon several factors—all of which must be evaluated. These factors include the roles played by air, water, earth materials, plants, and animals in transporting, concentrating, and dispersing the radioactive substances. Water is probably the most important of these agents; the prime mover of matter on and near the surface of the earth, it is the chief transporter of radioactive wastes, and the intake of radioactivity by plants, animals, and man will be influenced by the concentrations of radioactive substances and stable isotopes present in the water utilized by them. This paper deals with some of the variables which must be considered in studying the interaction of radioactive substances and the water resources of the nation, and discusses work which is being done to evaluate effects of these variables.

Contamination

The various methods proposed for the disposal of radioactive wastes fall into three general categories—controlled containment, partially controlled containment, and dispersal (*1*). Controlled containment consists of the storage of wastes in leakproof containers where the material is always under control until the radioactivity has decayed to safe levels. In partially controlled containment the wastes are stored in such a manner that, although leakage cannot be controlled, it is believed to be small. Burial or ocean disposal of solids not readily leached—such as glasses and ceramics—and liquid wastes pumped into deep aquifers are examples of this method. Dispersal consists in the release of material to the environment, in which reliance is solely upon dilution by air, water, and stable isotopes to reduce the concentration to safe levels. This method includes such practices as venting gases to the atmosphere, disposing of cooling water in rivers, and flushing

laboratory wastes into sewers. Fallout from nuclear weapons and the accidental release of radioactivity through equipment failure or human error might also be considered in this class as far as the effects upon water resources are concerned.

If perfect containment could be achieved, there would be no need for concern over the transport of radioactivity and its uptake—that is, retention after ingestion—by man. The cost would be prohibitive, however, except for small volumes of high-level wastes, so there can be no expectation that the problem can be solved by exclusive use of this method. In addition, no containment should be considered perfect, as there is always the possibility of rupture from man-made or natural cataclysms or from deterioration of the container.

In all other methods of waste disposal there is the possibility—almost the certainty—that water will become contaminated sooner or later. Gases and aerosols which have been released to the atmosphere will be dissolved in precipitation and carried with it into surface and ground waters. Materials which have been spread upon the surface—such as fallout—will be carried into surface water by runoff and into ground water by percolation. Percolating meteoric water will leach radioactive substances from buried wastes and transport them to ground water reservoirs. Wastes which have been dispersed through deep wells will be picked up and carried by the ground water. The dispersal of low-level wastes into streams will, of course, produce contamination of the water immediately.

Transport by Ground Water

In order to predict the movement of such contaminating materials, it is necessary to understand the mechanisms involved in the transport of matter by water. The important factors involved are the movement of water, the dispersal of dissolved and suspended matter in water, and the adsorption of substances by natural materials in contact with water.

The movement of ground water has been studied for many years and mathematical models have been worked out for many of the limiting circumstances. From these models it is possible to calculate approximately the distance which a waste introduced through an injection well will move in a given time—provided there is no interaction between the waste and the aquifer or its water. For example, in the idealized situation described by Theis (*2*), a uniform aquifer of thickness D (feet) is assumed to have a porosity of f (dimensionless) and a permeability P (gallons per day per square foot). The movement of the ground water is assumed to be under the influence of a natural hydraulic gradient I (dimensionless). If a waste which has the same density and viscosity as the ground water—and which undergoes no reactions with the natural materials—is injected uniformly at a rate Q (gallons per day), it will approach asymptotes parallel to the direction of flow and distant from the well by amount a. It will also approach as a limit a point b upgrade from the well. It will move downgrade a distance c in time t. These distances are given by the formulas:

$$a = \frac{Q}{2PID}$$

$$b = \frac{Q}{2\pi PID}$$

$$t = 7.48\left(\frac{f}{PI}\right)\left[c - b\,ln\left(1 + \frac{c}{b}\right)\right]$$

For a typical porous formation 100 ft thick, with a permeability of 10 gpd/sq ft, a porosity of 0.2, a hydraulic gradient of 10^{-3}, and a rate of injection of 1,325 gpd the limit *a* would be about 662 ft and the limit *b* about 210 ft. After 1,000 days, however, *c* would be only about 58 ft, and, as this represents the maximum in any direction, the wastes would occupy a volume approximately that of a cylinder 116 ft in diameter.

On the other hand, for a typical formation having a permeability of 500 gpd/sq ft and with all other quantities the same, *a* would be about 13 ft, *b* about 4 ft, and *c* about 353 ft after 1,000 days. Here the wastes would occupy an essentially elliptical cylinder with a major axis of 357 ft and a minor axis of 26 ft.

As one solution replaces another in a porous medium, the front between the two solutions becomes diffuse. This results in part from microvariations in the velocity of the moving fluids and, in part, from adsorption phenomena. Both of these mechanisms have been described mathematically for columns packed with uniform material and having longitudinal dispersion only.

Orcutt et al. (*3*) have shown that, for such a column packed with a nonadsorbing material, the normalized concentration of the effluent may be expressed as:

$$\frac{c}{c_o} = \frac{1}{2}\left[1 - erf\,\frac{1 - \dfrac{V}{vf}}{2\sqrt{\left(\dfrac{D_m}{LS}\right)\left(\dfrac{V}{vf}\right)}}\right]$$

where c is the concentration of the effluent; c_o, the concentration of the influent; V, the effluent volume; v, the bulk volume of the column as packed; f, porosity; D_m, the medium dispersion constant—probably a function of particle size, uniformity coefficient, and particle shape; L, column length; S, the linear flow rate of the liquid; and *erf*, the error function. This equation gives the familiar S-shaped breakthrough curve. The shape of the curve is determined by the dispersion constant, linear velocity, and path length and the time of arrival is determined by the flow rate and path length.

If the solid material in a column has the power to adsorb substances in solution or to undergo ion-exchange reactions with them, the diffuseness of the front may be much greater than indicated above. The movement of the front will be slowed also so that it will not reach a given point as soon as hydraulic considerations alone would predict. Again, using the approach of a column having only longitudinal dispersion, a mathematical treatment has been given by Thomas (*4, 5*). The breakthrough of a solute undergoing exchange reactions, plotted as a normalized concentration versus a normalized effluent volume, is described by a two-parameter family of curves which have been given by Heister and Vermeulen (*6*). The normalized concentration is again the ratio of effluent to influent concentrations:

$$\frac{C_A}{(C_A)_O}$$

in which the subscript refers to any one particular solute. The normalized effluent volume is:

$$T = (C_A)_O \frac{V - vf}{(q_A)_\infty \rho_B v}$$

where $(C_A)_O$ is the concentration of the component A in the influent; T is the normalized throughput; $(q_A)_\infty$, the equilibrium capacity of the solid for

the component A present in a solution having the concentration $(C_A)_O$; and ρ_B, the bulk density of the column as packed. The other symbols are as previously defined. This quantity is analogous to the term $\frac{V}{vf}$ in the previous equation. It has a value of 1 when the effuent volume has equaled the pore space plus that quantity required to saturate the solid with the adsorbed material under equilibrium conditions.

The dimensionless parameters are the column-capacity parameter:

$$s = \frac{kvf}{R} = \frac{k(L)}{s}$$

and the equilibrium parameter:

$$r_A = \frac{C_o}{C_o + (K''_A - 1)\,(C_A)_O}$$

where k is a general rate constant; R, the volumetric flow rate; s, the linear velocity of fluid; C_o, the total concentration of adsorbable solutes; and K''_A, the modified mass-action equilibrium constant for the exchange. The other symbols are as previously defined. The modified mass-action constant for the reaction:

$$\beta A^{+\alpha} + B_\alpha\cdot\text{clay} \rightleftarrows \alpha B^{+\beta} + A_\beta\cdot\text{clay}$$

is given by:

$$K''_A = \left[\frac{C_B{}^\alpha\, q_A{}^\beta}{C_A{}^\beta\, q_B{}^\alpha}\left(\frac{q_A+q_B}{C_A+C_B}\right)^{\alpha-\beta}\right]^{2/\alpha+\beta}$$

These equations may also be used for calculating the effects of physical adsorption if the terms are suitably defined.

The significance of these equations with respect to waste disposal has been discussed in greater detail by Orcutt et al (*3*).

From the foregoing discussion, it is seen that the ion-exchange properties of an aquifer are very important factors in the transport of radioactive substances by water. In order to predict the time of arrival of significant levels of radioactivity at any point, or to calculate heating effects of wastes dispersed underground, it will be necessary to consider the ion-exchange capacity of the aquifer and the various equilibrium and rate constants involved.

Transport by Surface Water

The transport of radioactive substances by surface water is quite another matter. Whereas ground water normally transports only substances in solution, surface water transports both dissolved solids and suspended solids. It is clear that the two types of material may not move at the same rate. The particles which remain in suspension probably are transported at the velocity of the water and, therefore, at the same rate as dissolved matter. The coarser material does not remain constantly in suspension, however, and hence, travels at a slower rate. In order to predict the rate of movement of radioactive material, it is therefore necessary to know how much is adsorbed upon the suspended solids in the stream.

Relation to Aquatic Biota

Uptake of radioactivity by aquatic biota is another important factor in the transport and concentration of radioactivity and one which may also depend upon the amount of radioactive material adsorbed on solid particles. Some plants derive their mineral foods directly from solution and others derive them from solid materials. In reaches of a stream where adsorption on suspended materials had decreased the concentration in solution, there probably would be less intake by biota.

In other reaches, where solids containing adsorbed substances had been deposited and where aquatic plants had rooted in them, the biological intake might be increased. The significance of these possibilities should be studied by the biologists and biochemists.

Treatment Aspects

A third important consideration having to do with adsorption of radioactive substances on suspended solids is its relationship to water treatment. The settling tanks and filters of water treatment plants remove suspended solids from the water. If a large part of the contamination were adsorbed on these solids, it too would be removed. This would constitute a safety factor for the water users in case of accidental contamination of a stream. An undesirable effect would be the buildup of activity on the filters downstream from a plant releasing radioactive wastes. This should be evaluated before beginning continuous disposal into any stream.

Dispersal in Streams

The dispersal from slugs of dissolved substances injected into streams has been studied by Glover (*7*). Under conditions such that no loss occurred by adsorption, he found that the peak concentration of a tracer varies inversely as the square root of the distance traveled. The time required for the peak to reach a given point is inversely proportional to the velocity of the stream. As mentioned previously, fine suspended sediment with adsorbed radioactive material would probably follow the same laws.

If the velocity of a stream decreases, part of its sediment load is deposited on the bottom. Any radioactive material adsorbed by such sediment may in time build up to undesirable concentrations in these deposits. This material may remain for long periods until a flood, accompanied by high velocities, scours the stream bottom.

Again, it is seen that in order to predict the rate of movement and concentration of radioactive wastes it is necessary to know the ion-exchange properties of substances in contact with the water which is carrying the contamination. It also will be necessary to study the mechanisms of sediment transport, bed-suspended load exchange, and other phenomena.

Ion-Exchange Studies

In order to evaluate the effects of radioactive-waste disposal programs upon the important resource, water, USGS has begun studies of the various factors involved. Among these is a study of the ion exchange of certain fission products and natural materials.

The natural materials responsible for much of the ion-exchange capacity of rocks, soils, and waterborne sediments are the clay minerals. It was therefore decided to begin the studies with some typical clays. Five American Petroleum Institute reference (*8*) clays were chosen—kaolinite No. 4, illite No. 35, halloysite No. 12, montmorillonite (white) No. 11, and montmorillonite (bentonite) No. 21. These represent four types of clay lattices and have a wide range of exchange capacities.

Four methods for determining total cation-exchange capacity have been investigated. These are:

1. The ammonium acetate method (9) in which the clay is saturated with ammonium acetate and washed free of excess ions. (The amount of ammonium ion adsorbed is then determined by the Kjeldahl method.)

2. The manganese method *(10)* in which the clay is saturated with manganese chloride and washed free of excess ions. (The manganese is then elutriated with ammonium acetate and determined either colorimetrically or volumetrically.)

3. The radiocesium method in which the clay is saturated with cesium chloride tagged with Cs^{137} and washed free of excess ions. (The radioactivity on the clay is then determined by gamma counting.)

4. The radiostrontium method in which the clay is saturated with strontium nitrate tagged with Sr^{90} and washed free of excess ions. (The radioactivity adsorbed on the clay is then determined by beta counting.)

Two different techniques were used in determining the cation-exchange capacity by these methods. The batch technique involved treating the clay three times with a concentrated solution of the appropriate ion and measuring the amount adsorbed. The exchange capacity was calculated with the assumption that the reaction had gone to completion. The isotherm technique involved equilibrating the clay with solutions of the ions at various concentrations. The amount adsorbed was plotted against the equilibrium concentration of the solution and the constant value reached at the higher concentrations was taken as the exchange capacity. Results obtained from these experiments are shown in Table 1.

TABLE 1

Total Ion-Exchange Capacities of Various Clays*

Clays	Ammonium		Manganese		Radiocesium	Radiostrontium	
	Isotherm Technique	Batch Technique	Isotherm Technique	Batch Technique	Isotherm Technique	Isotherm Technique	Batch Technique
Kaolinite	0.11				0.10	0.10	0.10
Illite	0.19	0.25			0.22		
Halloysite	0.63				0.61		
Montmorillonite No. 11	0.90	0.90	0.90	0.90	0.98	0.82	
Montmorillonite No. 21	1.18				1.41	1.42	1.59

* Expressed in milliequivalents per gram.

The effect of different concentrations of sodium and calcium upon the adsorption of carrier-free cesium and strontium by the illite, halloysite, and montmorillonite No. 21 was investigated. In these experiments, the clay was first transformed into a sodium or calcium clay by saturating it with an appropriate salt. Solutions of sodium or calcium chloride containing the carrier-free tracer were then shaken for 17 hr with sufficient clay to give a suspension of about 4,000 ppm and the amount of radioactivity adsorbed was determined by counting. The results are shown in Fig. 1–3.

Distribution coefficients for the exchange of larger amounts of cesium or strontium for sodium or calcium were determined in a similar manner except that strontium carrier was added to a

concentration of 10^{-4} molar or cesium carrier was added to a concentration of 10^{-5} molar. The results of these experiments are shown in Table 2 where they are compared with results from the "carrier-free" experiments. The distribution coefficients were calculated according to the equation (*11*):

$$K_d = \frac{f_a}{f_l} \cdot \frac{V}{M} = \frac{f_a}{1 - f_a} \cdot \frac{V}{M}$$

where K_d is the distribution coefficient; f_a, the fraction of tracer adsorbed; f_l, the fraction of tracer not adsorbed; V, the volume of solution (in milliliters); and M the mass of clay (in grams).

Discussion of Results

The four methods studied for determining total exchange capacities yield comparable results. The ammonium method is simpler than the manganese method and somewhat less subject to error. The advantages of gamma counting make the radiocesium method preferable to the radiostrontium method. The choice between the ammonium and radiocesium methods is more difficult; the radiocesium method is somewhat easier, but the precision of the ammonium method may be somewhat greater.

The percentage of carrier-free cesium adsorbed by clay decreases, as expected, when the concentration of calcium or sodium is increased. The effects of the two ions are very similar, sodium having only a slightly greater effect than calcium. This indicates that as far as ion exchange is concerned, cesium resembles sodium only slightly more than it does calcium. In most natural waters, calcium and sodium are the predominant cations; thus, as a first approximation, the adsorption of small quantities of cesium would depend only upon the total concentration—in equivalents per million—of ions in the water. Additional studies of these systems as well as of magnesium- and potassium-clay systems will indicate the reliability of such an approximation.

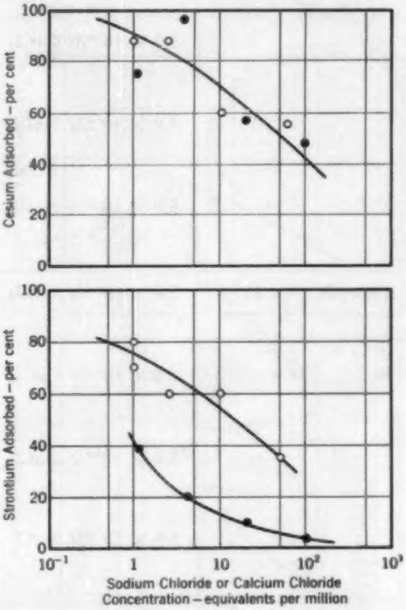

Fig. 1. Percentage Adsorption of Cesium and Strontium on Illite No. 35

Points plotted with open circles are for sodium chloride; those plotted with closed circles are for calcium chloride.

The concentration of calcium has a much greater effect upon the adsorption of strontium than has the concentration of sodium. This is due, of course, to the marked resemblance between calcium and strontium, the ions

TABLE 2

Distribution Coefficients for the Adsorption of Strontium and Cesium on Clays

Clay	Initial Composition of Solution		Distribution Coefficient at Equilibrium	
	Ca^{++} or Na^{+}	Sr^{++} or Cs^{+}	Sr^{++}	Cs^{+}
Illite No. 35	$5.7 \times 10^{-4} M$ $CaCl_2$	Carrier-free*	160	840
		$10^{-4} M$ $Sr(NO_3)_2$	170	
	$5.0 \times 10^{-2} M$ $CaCl_2$	Carrier-free	5.5	240
		$10^{-4} M$ $Sr(NO_3)_2$	3.1	
		$10^{-5} M$ $CsCl$		240
	$9.9 \times 10^{-4} M$ $NaCl$	Carrier-free	1,000	2,000
		$10^{-4} M$ $Sr(NO_3)_2$	470	
		$10^{-5} M$ $CsCl$		550
	$5.0 \times 10^{-2} M$ $NaCl$	Carrier-free	150	330
		$10^{-4} M$ $Sr(NO_3)_2$	103	
		$10^{-5} M$ $CsCl$		240
Halloysite No. 12	$5.4 \times 10^{-4} M$ $CaCl_2$	Carrier-free	120	1,800
		$10^{-4} M$ $Sr(NO_3)_2$	120	
		$10^{-5} M$ $CsCl$		320
	$5.0 \times 10^{-2} M$ $CaCl_2$	Carrier-free	2.8	1,800
		$10^{-4} M$ $Sr(NO_3)_2$	2.5	
		$10^{-5} M$ $CsCl$		150
	$5.6 \times 10^{-4} M$ $NaCl$	Carrier-free	$> 2 \times 10^{4}$	1,500
		$10^{-4} M$ $Sr(NO_3)_2$	200	
		$10^{-5} M$ $CsCl$		160
	$5.0 \times 10^{-2} M$ $NaCl$	Carrier-free	2,000	970
		$10^{-4} M$ $Sr(NO_3)_2$	30	
		$10^{-5} M$ $CsCl$		120
Montmorillonite No. 21	$1.5 \times 10^{-3} M$ $CaCl_2$	Carrier-free	450	
		$10^{-4} M$ $Sr(NO_3)_2$	760	
	$2.4 \times 10^{-3} M$ $CaCl_2$	Carrier-free		130
	$5.1 \times 10^{-2} M$ $CaCl_2$	Carrier-free	20	
		$10^{-4} M$ $Sr(NO_3)_2$	14	
	$5.2 \times 10^{-2} M$ $CaCl_2$	Carrier-free		54
		$10^{-5} M$ $CsCl$		40
	$2.0 \times 10^{-3} M$ $NaCl$	Carrier-free	500	
	$3.5 \times 10^{-3} M$ $NaCl$	Carrier-free		350
		$10^{-5} M$ $CsCl$		280
	$5.3 \times 10^{-3} M$ $NaCl$	Carrier-free	500	150
		$10^{-5} M$ $CsCl$		100

* Carrier-free $Sr^{90}Cl_2$ or $Cs^{137}Cl$, obtained from Oak Ridge National Laboratory, was used without further treatment.

of which compete for exchange positions on an almost equal basis. Predictions concerning the adsorption of traces of strontium from a natural water would therefore necessitate consideration of the sodium-calcium ratio as well as the total concentration of dissolved substances. Additional work on these systems is also needed.

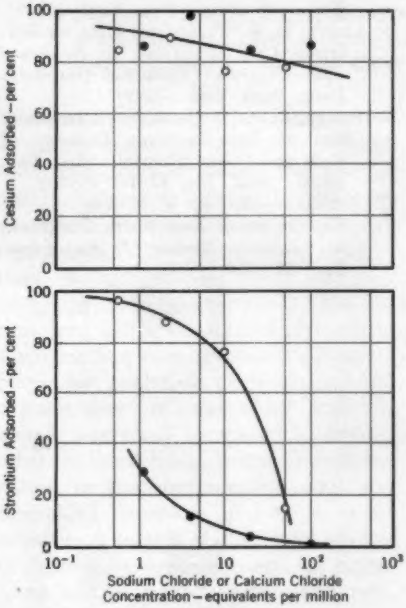

Fig. 2. Percentage Adsorption on Halloysite No. 12

Open circles are for sodium chloride; closed for calcium chloride.

The distribution coefficients for the adsorption of cesium or strontium show that both the concentration of the radioactive substance and the concentration of sodium and calcium affect the amount of radioactivity adsorbed. In general, changes in the total concentration of the solution have a greater effect than changes in the cesium or strontium concentration within the range to be expected in most natural waters. This is particularly noticeable in the effect of calcium concentration on the adsorption of strontium. The most significant exception to this is in the adsorption of cesium on halloysite, where the cesium concentration is the determining factor. Much more

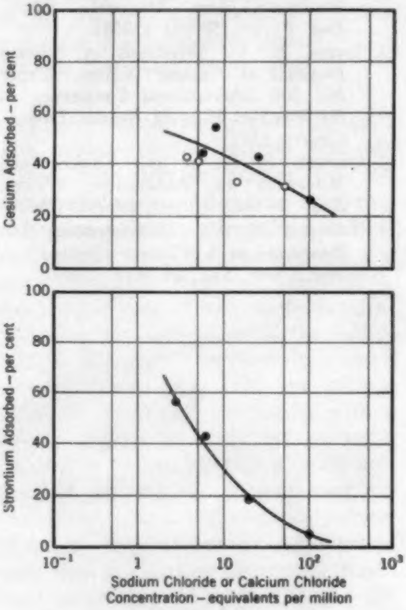

Fig. 3. Percentage Adsorption on Montmorillonite No. 21

Open circles, sodium chloride; closed, calcium chloride.

work is needed in order to evaluate the distribution coefficients under various conditions which might be met when radioactive wastes are dispersed into the environment. It will also be necessary to study many more of the hazardous fission products in a similar manner.

This work is being continued by the USGS in the hope that it will provide

the basis for approximate calculations concerning the transport of radioactive wastes in different environments. These estimates would aid greatly in the selection of methods and sites for waste disposal.

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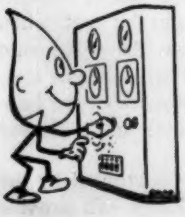

Determination of Radionuclides in Low Concentrations in Water

Bernd Kahn and S. A. Reynolds

A paper presented on Mar. 21, 1958, under the sponsorship of the AWWA, at the Engineers Joint Council's Nuclear Eng. and Science Congress, Chicago, Ill., by Bernd Kahn, Sr. Asst. San Engr., USPHS, Washington, D.C., and S. A. Reynolds, Leader, Radiochemistry Group, Anal. Chemistry Div., Oak Ridge National Lab., Oak Ridge, Tenn.

IN this discussion, a gamma spectrometric technique and four volume reduction methods—each utilizing a different concentration technique—are described. Zirconium and niobium are concentrated by precipitation, strontium is concentrated with an ion-exchange resin, ruthenium by distillation, and iodine by solvent extraction. Each method was developed to meet a particular analytical requirement—the concentration of zirconium and niobium was small compared to that of other radionuclides, hence decontamination in the concentration step was desirable; strontium had to be separated in at least a slightly acid system to destroy its versene complex; ruthenium was in mixed anionic and nonionic complexes and had to be converted to a common form; and iodine was present in much larger concentration than other tracers, the requirement for its analysis being only rapid concentration. These methods were used in preference to evaporation because they were, in general, faster, subject to fewer losses, and more selective for the particular radionuclides.

Concentration Methods

In developing the concentration methods, tap water containing the appropriate radioactive tracer was used. The acidity of the sample was adjusted, the isotopic carrier for the radionuclide was added, and oxidizing or reducing agents were added to convert carrier and radionuclides to the same oxidation state. Concentration consisted of one of four methods: precipitating the carrier with the radionuclide and dissolving both in a small volume, absorbing them on cation-exchange resin and elutriating with a small volume, distilling into a small volume or extracting into a small volume of an organic solvent and re-extracting into a still smaller volume of water. The carrier and radionuclide were then purified by previously developed procedures (*1*; p. 1417) and the final precipitate was weighed and counted. The count rate was corrected for loss during the procedure by multiplying by the ratio of the initial to the final weight of the carrier. It was then compared to the initial count rate of the tracer. The amounts of tracer added and recovered for these methods are compared in Table 1.

Because decontamination from the other major long-lived fission products was a requirement for the zirconium-niobium procedure, the two ions were precipitated as phosphates from an

TABLE 1

Tracer Recovery in Duplicate Analyses

Radionuclide	Carrier Yield *per cent*	Activity Added *cpm*	Activity Recovered *cpm*	Recovery *per cent*
Zirconium 95	80	40,000 ± 1,000 γ	39,000 ± 2,000 γ	97.5 ± 5.6
Niobium 95	50	52,000 ± 1,000 γ	53,000 ± 1,000 γ	101.9 ± 2.7
Strontium 89	50	5,500 ± 200 β	5,200 ± 300 β	94.5 ± 6.5
Ruthenium 106*	80	115,000 ± 1,000 γ	114,000 ± 2,000 γ	99.1 ± 1.9
Iodine 131	70	86,000 ± 2,000 γ	88,000 ± 1,000 γ	102.3 ± 2.6

* Obtained as ruthenium trichloride ($RuCl_3$) plus ruthenium dichloride ($RuCl_2$). All tracers are from the Isotopes Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

acid solution. To test the decontamination, a mixture of cerium 144, strontium 90, yttrium 90, cesium 137, and ruthenium 106—each having approximately the same counting rate—was added to water containing no zirconium or niobium tracer, and the zirconium and niobium carriers were counted after concentration and at the end of the procedure. The initial count of 1.2×10^8 had been reduced to 8.0×10^5 after concentration and to 210 and 630 in the final zirconium and niobium precipitates, respectively, yielding overall decontamination factors of 600,000 and 200,000.

The samples submitted for ruthenium analysis consisted of both cationic ruthenium solutions and of ground water which had traveled through several hundred feet of shale; they contained ruthenium in nonionic or anionic forms only. Before distillation, the ruthenium was therefore converted

TABLE 2

Tracer-Carrier Interchange of Ruthenium 106

Interchange Conditions	Activity Added *cpm*	Activity Recovered *cpm*	Recovery *per cent*
Cationic Ruthenium in Chloride Solution			
100 ml H_2SO_4 + 1.2 g $KMnO_4$; distilled 15 min	115,000	113,400	98.6
28 g KOH + 1.2 g $KMnO_4$; boiled 60 min	115,000	114,400	99.5
Anionic and Nonionic Ruthenium in Ground Water			
100 ml H_2SO_4 + 1.2 g $KMnO_4$; distilled 15 min	127,800	8,700	6.8
28 g KOH + 1.2 g $KMnO_4$; boiled 30 min	127,800	79,200	61.9
28 g KOH + 1.2 g $KMnO_4$; boiled 60 min	118,500	100,900	85.1
56 g KOH + 1.2 g $KMnO_4$; boiled 120 min	123,400	108,500	87.9
112 g KOH + 1.2 g $KMnO_4$; boiled 120 min	123,400	121,000	98.0
112 g KOH + 1.2 g $KMnO_4$; boiled 60 min	122,400	118,400	96.7
168 g KOH + 1.2 g $KMnO_4$; boiled 120 min	122,400	121,100	98.9

to a common ruthenate (RuO_4^{--}) state by boiling with potassium permanganate in a sodium hydroxide solution (*2*). The dependence of interchange between carrier and radionuclide on the conditions under which the ruthenium is boiled is shown in Table 2. No loss by volatilization of ruthenium occurred as long as the solution was basic.

Strontium 90, because of its low maximum permissible concentration in water (8×10^{-7} μc/ml), must be detected with greater sensitivity than the other fission products. To do so, an ion-exchange concentration procedure (*3*) developed for liter samples was adapted for 10-liter samples. The major problem in the procedure is the separation of strontium from the natural calcium in water; to attain this separation, strontium nitrate is precipitated three times from suitable concentrations of fuming nitric acid.

Because the major requirements for the iodine analysis were speed and volume reduction rather than decontamination and perfect reproducibility, only one extraction—and not the two described (*1*; p. 1625)—was made. The iodine was counted as a liquid instead of precipitating silver iodide and weighing and counting this precipitate. The recovery of iodine in a number of experiments was sufficiently constant to permit use of the figure 0.70 as the fraction recovered for all samples.

The concentration methods for various elements are as follows.

Zirconium and Niobium

To 2 liters of water in a 3-liter beaker, add 50 ml concentrated nitric acid and approximately 20 mg each of zirconium and niobium carriers. Heat to more than 85°C and add 5 ml concentrated phosphoric acid to precipitate phosphates of zirconium and niobium. Stir and let precipitate settle for 30 min. Decant almost all of the supernatant solution. Transfer the precipitate with the remaining supernatant—approximately 40 ml—to a 50-ml centrifuge tube *, centrifuge, and discard the supernatant. Wash the precipitate twice with 20 ml 3*M* hydrochloric acid.

Dissolve the precipitate in 2 ml concentrated hydrofluoric acid. Dilute to 10 ml and add 20 mg lanthanum carrier to precipitate the lanthanum fluoride "scavenger." Centrifuge and decant the supernatant to another tube. Add 1 ml barium nitrate—100 mg/ml—to precipitate barium fluozirconate and centrifuge and decant supernatant to tube.

Dissolve the zirconium precipitate in 2 ml saturated boric acid plus 1 ml concentrated nitric acid and reprecipitate by adding 1 ml hydrofluoric acid. Then follow the original procedure (*1*; p. 1499), dissolving the barium fluozirconate with boric acid and hydrochloric acid, removing the barium by precipitating barium sulfate, precipitating the zirconium with cupferron, and heating the precipitate to obtain zirconium dioxide.

To the supernatant containing niobium, add 10 mg zirconium carrier and 1 ml barium nitrate to precipitate the zirconium scavenger. Centrifuge and discard the precipitate, decanting the supernatant to a tube. Then follow original procedure (*1*; p. 1523),

* Tubes used are of a resistant plastic called Lusteroid, manufactured by the Lusteroid Container Co., Maplewood, N.J.

precipitating niobium with ammonium hydroxide, washing the precipitate, dissolving the precipitate in oxalic acid, and precipitating the niobium as the pentoxide by destroying the oxalic acid with potassium chlorate. The niobium pentoxide is then heated to constant weight.

Strontium

To 10 liters of water, add 1 ml 1*M* hydrochloric acid and approximately 20 mg strontium carrier. Pass upflow, at 10 ml/min, through 25 g (moist weight) of resin (hydrogen form) * which has been washed with 1*M* hydrochloric acid and with distilled water. Elutriate strontium from the resin with 100 ml 14*M* nitric acid. Add 190 ml fuming nitric acid, stir, and cool in order to precipitate strontium nitrate; then centrifuge and discard the supernatant. Dissolve precipitate with 5 ml of water and precipitate strontium nitrate again by adding 20 ml fuming nitric acid. Repeat solution and precipitation and then follow original procedure (*1*; p. 1460), precipitating the ferric hydroxide scavenger, precipitating barium chromate if necessary, and then precipitating strontium oxalate from the basic solution.

Ruthenium

To 1 liter of water in a 2-liter flask, add 168 g potassium hydroxide, approximately 20 mg ruthenium carrier, and 1.2 g potassium permanganate. Boil the solution for 2 hr, cool in an ice bath, and very carefully (to prevent heating the solution excessively) add 100 ml concentrated sulfuric acid. Close the flask with a ruthenium condenser (*1*; p. 1549) and distill RuO_4 into 20 ml 6*M* sodium hydroxide for 15 min by boiling the ruthenium solution.

Then follow the original procedure (*1*; p. 1549), precipitating the ruthenium as ruthenium dioxide (RuO_2) by heating the sodium hydroxide solution with ethyl alcohol, dissolving the ruthenium in hydrochloric acid, and reducing it to ruthenium metal by adding magnesium metal.

Iodine

To 250 ml of water in a 500-ml separatory funnel, add approximately 20 mg iodine carrier (as the iodide). Oxidize to iodate with 2 ml of 5 per cent sodium hypochlorite. Add 10 ml concentrated nitric acid and 5 ml hydroxylamine hydrochloride to reduce iodine to the elemental form. Add 20 ml carbon tetrachloride and shake 1–2 min. Transfer the organic phase to a 30-ml separatory funnel.

To the carbon tetrachloride add 2 ml of water containing 2 drops of 1*M* sodium bisulfite to reduce the iodine to the iodide. Shake until the organic phase is colorless and discard it. Transfer the aqueous phase to a 3-ml culture tube and count in a well type scintillation counter.

Discussion

The concentration methods described are applicable to water analyses but, with the possible exception of concentration by ion exchange, can be extended to various aqueous solutions. Their sensitivity with ordinary counting equipment is approximately 10^{-5} μc per sample—that is, 10^{-8} μc/ml for a liter sample. With stable, low-background counting devices, the sensitivity can be increased approximately

* Dowex-50, a product of the Dow Chemical Co., Midland, Mich.

100 times. For different analytical requirements, some changes in the methods may be desirable. For instance, strontium 90—rather than a mixture of strontium radioisotopes—is not determined directly but, instead, yttrium 90 is permitted to grow into the solution containing the purified strontium and is then separated and counted (*4*). Because strontium is not counted, there is no restriction on the amount of strontium carrier and, hence, more carrier can be used and the effect of a small calcium impurity resulting from high calcium concentrations in the sample can be decreased. Iodine, if accompanied by other radionuclides in appreciable quantities, can be further purified by repeated extractions and precipitation as the silver salt (*1*, p. 1625; *4*). Within limitations, quantities may be varied to accommodate suitable sample volumes. The methods described have been used routinely to determine the concentration of strontium, ruthenium, zirconium, and niobium in streams carrying waste effluents from the Oak Ridge National Laboratory; the concentration of ruthenium in ground water surrounding waste seepage pits at the same location; and the concentration of iodine in a study of the flow pattern of the Clinch River in Tennessee.

Gamma Spectrometric Method

Gamma scintillation spectrometry has been used by several workers for identification and determination of radionuclides (*5–8*). The basic principles, apparatus, and methods of application have been described before (*9, 10*). Advantages of the technique are that it is nondestructive, both identifications and measurements may be made, and, many times, no special preparation of sample is necessary—that is, the only time involved is that required for counting. The principal disadvantage lies in the occasional interference of the photopeaks or secondaries of one gamma spectrum in measurement of another.

The spectrometer employed in the work described here consists of a 3 × 3-in. "thallium-activated" sodium iodide crystal, mounted on a 3-in. photomultiplier tube, and sealed in thin aluminum foil. The detector is housed in a steel shield 4 in. thick. Electronic components consist of a preamplifier, linear amplifier, and a 20-channel analyzer with scalers. All components of the system are commercially available.

TABLE 3

Typical Efficiencies of Scintillation Spectrometer

Nuclide	Gamma Energy *mev*	Efficiency—*per cent*	
		Planchet	Flask*
Cr^{51}**	0.32	25	14
Cs^{137}	0.66	13	7
Co^{60}	1.33	7	4

* A 250-ml Erlenmeyer containing 100 ml of solution.
** Corrected for occurrence of gamma in disintegrations on the order of 9 per cent.

Dry samples have been placed in planchets mounted directly on the crystal and liquid samples have been contained in various types of bottles or flasks. The best type of container has a bottom of large area, to insure that a maximum amount of the solution is near the detector. A 250-ml Erlenmeyer flask has been used in this way to contain 100-ml solution samples.

Sensitivity

The *efficiency* (expressed as a percentage) of a scintillation spectrometer

for a particular gamma-emitting nuclide may be defined as

$$E = \frac{100\,(\text{photopeak area counts per minute})}{\text{disintegrations per minute}}.$$

Approximate efficiencies for three gamma-emitters are shown in Table 3. All values are basically experimental, but a knowledge of decay schemes is required in order to adapt them to the method of presentation in the table.

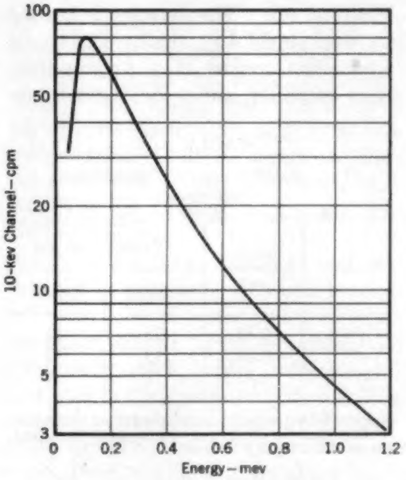

Fig. 1. Background of Spectrometer as a Function of Energy

Sensitivity of detection of radioelements depends, in part, on background in region of photopeak.

Because cesium 137 is an important constituent of waste water, calculations were made of detectable amounts of this nuclide under various conditions. The minimum quantity measurable by a spectrometer was estimated by considering the background in the region of the cesium photopeak, its random variation characteristic during a reasonable period of counting, and the efficiency (Table 3). It was considered that a net counting rate equivalent to three times the standard deviation of the background is significant. The standard deviation of the net counting rate is then on the order of 50 per cent. The spectrometer described above has a background of ~ 90 cpm in the channels covered by the photopeak of cesium 137. This device is in an area of moderately high external radiation and it is used for samples of various levels.

TABLE 4

Limits of Cs^{137} Measurement

Background *cpm*	Time	Standard Deviation *cpm*	*dpm*	*μμc*
		Flask		
90	30 min	1.70	70	32
90	8 hr	0.43	18	8
9	8 hr	0.13	6	3
		Planchet		
90	30 min	1.70	38	17
90	8 hr	0.43	10	5
9	8 hr	0.13	3	1.4

It should be feasible to reduce the background tenfold by operating in a low-background area and giving careful attention to structural materials—for example, by using sodium iodide of low potassium content. The results of calculations, assuming backgrounds of 90 and 9 cpm and using the efficiencies from Table 3 are shown in Table 4. It may be concluded that it would be feasible to make direct measurements of cesium 137 at a level on the order of 3×10^{-8} μc/ml. Measure-

ments have been made with present equipment at a level in the vicinity of 100 disintegrations per minute (dpm), confirming part of the data of Table 4.

When radium 226, a hazardous nuclide, is in equilibrium with its short-lived daughters, most of its disintegrations are followed by emission of 0.61-mev photons from Bismuth 214. These can be detected with about the same efficiency as photons from cesium 137. If a 1-liter sample is concentrated, a radium level of 1–3 $\mu\mu$c per liter could be measured. This is an order of magnitude lower than the maximum permissible concentration of this nuclide—40 $\mu\mu$c per liter. Other radioelements are detected with different sensitivities, depending upon the background in the region of their photopeaks (Fig. 1) and the efficiency of detection. Further, the sensitivity for a nuclide is affected adversely by the presence of other gamma-emitting components—particularly those of higher energy.

Applications

A number of analyses of river water have been done by spectrometry. Samples as large as 100 liters were taken, silt was removed by filtration and analyzed separately, and the filtrate was concentrated by evaporation. Table 5 indicates the range of results on typical samples taken several miles downstream from the Oak Ridge National Laboratory. Many other higher-level samples—of water, mud, airborne materials, and others—have been analyzed by spectrometry.

Future Work

A "low-level" laboratory is being planned, which will permit work in a much weaker external-radiation field and with less chance of "contamination" of samples. Use of an analyzer with 100 or more channels will materially reduce counting times. A sample container with a 3 × 3-in. reentrant well in the bottom will permit the direct measurement of 1-liter samples at rather high efficiency. Anticoincidence techniques will permit the measurement of beta activity at a level of about 1 cpm.

TABLE 5

Typical Analyses of River Water

Component	Concentration $\mu\mu c/l$		Maximum Permissible Concentration $\mu\mu c/l$
	In Solution	In Silt	
Cs^{137}	3–7	4–15	2×10^{6}
Co^{60}	0–1.5	1.5–2	4×10^{5}
Ru^{106}	0–14	<3	10^{5}
Ce^{144}	0–4	0–2	10^{5}
$Zr\text{-}Nb^{95}$	<2	<1	

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Correction

The paper "Ohio River Water Quality and Flow" by Edward J. Cleary and David A. Robertson Jr. (March 1958 JOURNAL, Vol. 50, pp. 399–409) contained an editorial error. The illustration shown as Fig. 2 (p. 404) was incorrect. The correct illustration is shown below.

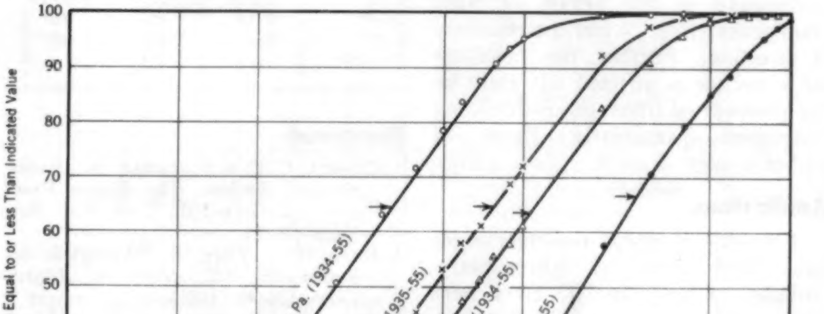

Fig. 2. Flow Duration Patterns for the Ohio River

Curves indicate frequencies of occurrence for flows of various magnitudes at four gaging stations. Arrows indicate the computed average flows. Information was developed by ORSANCO from daily flow records of the USGS.

Use of the Gamma Spectrometer in the Identification of Radionuclides in Water

G. Richard Hagee, Abraham S. Goldin, and Conrad P. Straub

A paper presented on Mar. 21, 1958, under the sponsorship of AWWA, of the Engineers Joint Council's Nuclear Eng. and Science Congress, Chicago, Ill., by G. Richard Hagee, Research Physicist, presently assigned to Ohio State Univ., Columbus, Ohio, Abraham S. Goldin, In Charge, Radiochem. Analyses, and Conrad P. Straub, Chief, Radiological Health Program. All are on the staff of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

It has become increasingly apparent in recent years that the determination of gross radioactivity does not adequately characterize the radiological nature of water. The identification of the radioactive materials present is necessary for a meaningful assessment of the potential health hazard of the contamination present. Gamma scintillation spectrometry offers a possible means of simplifying this identification. In addition, because gamma radiation is affected by self-absorption to only a very minor degree, this technique permits the utilization of large samples with much less stringent sample preparation techniques than are required for beta or alpha counting.

Gamma spectrometry, unfortunately, is not a panacea for the problems involved in radioactivity measurements. A number of the more important radionuclides, including strontium 90, strontium 89, yttrium 91, phosphorus 32 and hydrogen 3, either do not emit gamma radiation or do so only in a small percentage of the radioactive disintegrations. Furthermore, gamma measurements appear to be somewhat less sensitive than alpha or beta measurements and there is some interference of one gamma radiation with another in complex mixtures.

Basis

The basis for gamma spectrometry is the fact that gamma photons are emitted in a characteristic line spectrum consisting of a few discrete energies. Figure 1 shows the energy levels of cesium 137 and iodine 131, and the gamma radiations emitted. The utilization of these spectra for identification requires detectors capable of an output proportional to the gamma energy.

Gamma photons interact with matter in one of three ways—two of which are of importance in gamma spectroscopy. These interactions may produce a secondary (photo-) electron carrying the full gamma energy, they may produce a secondary (Compton) electron carrying less than the full gamma energy plus a secondary gamma photon, or—less important—they may produce a positron-electron pair. Figure 2 illus-

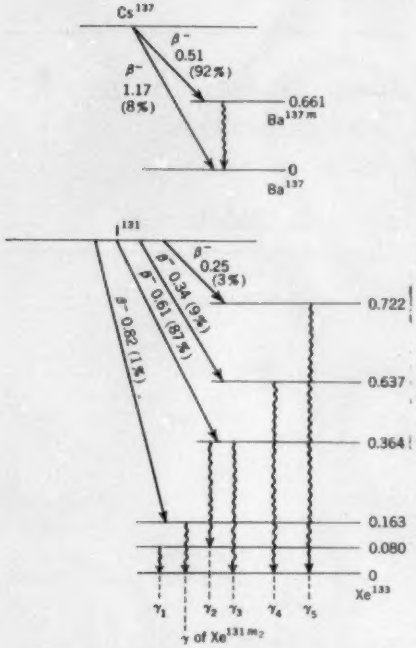

Fig. 1. Energy Levels

Levels are shown for cesium 137 and iodine 131. Gamma radiations are also indicated.

trates these interactions. The secondary electrons then transfer their energy to the scintillating crystal, producing light photons, the number being proportional to the energy. By the use of suitable light-collecting and electronic apparatus, a pulse is obtained which is proportional to the amount of energy lost by the incident gamma photon in the crystal.

The initial line spectrum of the gamma emitter is thus modified as shown in Fig. 3 for the cesium 137 spectrum. There are two factors involved in this spectrum modification—a broadening of the line itself (resolution) and a degradation of the spectrum caused by incomplete capture of the energy of the photon.

Instrumentation

Almost all gamma spectroscopy systems now use a thallium-activated sodium iodide crystal, a photomultiplier tube, and a linear amplifier to produce a pulse proportional to the gamma energy. The resulting pulses are then usually fed into a unit which: [1] responds to all pulses larger than a preset value (discriminator), [2] responds to all pulses between two preset values (single-channel analyzer), or [3] sorts pulses into a number of channels depending on their size (multichannel analyzer). Figure 4 illustrates a single-, a 20-, and a 100-channel analyzer. The full spectrum can be obtained with any of these instruments. The multichannel analyzer gives the full spectrum in a single run or a few runs, the single-channel analyzer requires a channel-by-channel plot, and the discriminator requires plotting of the difference between consecutive counts.

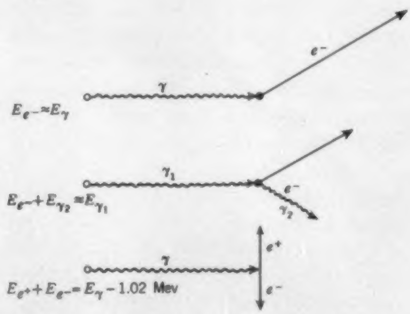

Fig. 2. Interactions of Gamma Photons

The top reaction produces a photoelectron; that in the middle, a Compton electron; and the reaction at the bottom, a positron-electron pair (least important).

Application to Water Samples

In the isotope samples presented here, interest has been primarily in fission product contamination. Some of the major fission products are listed in Table 1, together with their half-lives and characteristic gamma radiations. The more important radiations are shown italicized.

The gamma spectra obtained on some environmental samples analyzed at the Robert A. Taft Sanitary Engineering Center at Cincinnati are shown in Fig. 5–9. Figure 5 shows spectra for three samples, all of which are rather old and have relatively simple spectra. These samples were of soil from the Nevada nuclear weapons testing area, rain, and cistern water. All show a number of isotopes characteristic of rather old fission products—cerium 144, zirconium-niobium 95, and ruthenium 106. The two peaks—labeled "unknown" and originally believed to be the result of induced radioactivity—were found to arise from the misdirection of a small fraction of pulses ten channels higher than they should have gone. The number of pulses misdirected in this way varied from 2 to 5 per cent and the size of the actual peak was, therefore, decreased by this amount. The multiple peak for cerium 144 (shown in Fig. 6 as well as Fig. 5) resulted from an erratic storage of low-energy pulses which led to a false splitting of low-energy peaks. This destroyed any possibility of quantitative determination of gamma emitters below about 200 kev—such as cerium 144. The identification of these isotopes, however, remains valid.

TABLE 1

Half-Lives and Characteristic Gamma Radiations of Major Fission Products

Nuclide	Half-Life	Gamma Radiations *Mev**
Sr^{89}	53 days	None
$Sr\text{-}Y^{90}$	28 years	None
Y^{91}	58 days	None (<0.5%)
$Zr\text{-}Nb^{95}$	63 days	*0.72*, 0.74
$Ru\text{-}Rh^{103}$	41 days	*0.040*, *0.50*, 0.61
$Ru\text{-}Rh^{106}$	1 year	*0.51*, *0.62*
I^{131}	8 days	0.080, 0.28, *0.36*, 0.64, 0.72
$Cs\text{-}Ba^{137}$	33 years	*0.66*
$Ba\text{-}La^{140}$	13 days	0.49, 0.82, *0.03*, *0.16*, 0.30, 0.54, *1.60*
Ce^{141}	33 days	*0.14*
$Ce\text{-}Pr^{144}$	275 days	*0.13*
Nd^{147}	11 days	*0.09*, 0.31, 0.39, 0.52

* Million electron volts; italic figures are for the more important radiations.

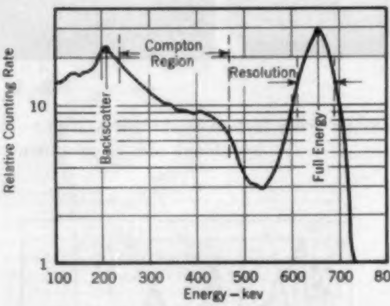

Fig. 3. Cesium 137 Spectrum

Factors involved in this spectrum modification are a broadening of the line itself and a degradation of the spectrum.

Figure 6 illustrates the spectrum obtained from a sample of cistern sludge approximately 18 months after collection. Because of the concentration of isotopes in this material relative to the concentrations existing in water samples, the gamma peaks are more distinct. The predominant nuclides are cerium 144 and cesium 137, with a small peak in the region corresponding to ruthenium 106 and a step in the curve which is probably indicative of

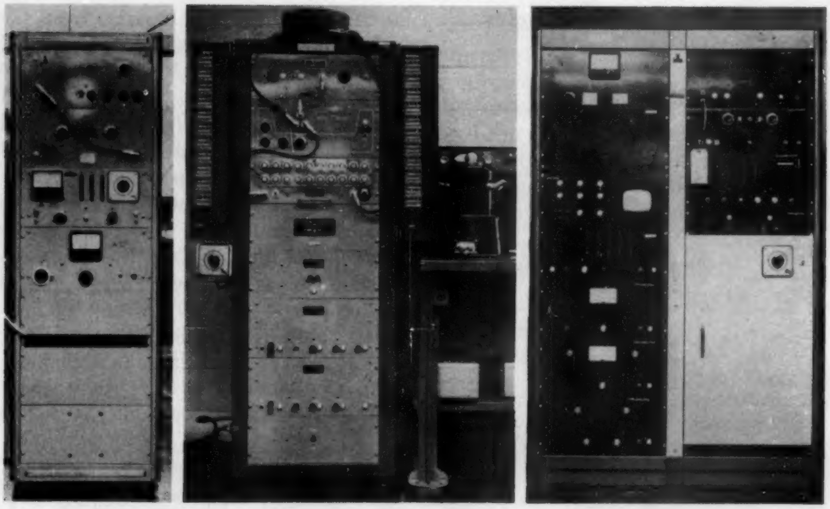

Fig. 4. Analyzers

Shown from left to right are a single-, a 20-, and a 100-channel analyzer. The full spectrum can be obtained with any of these instruments.

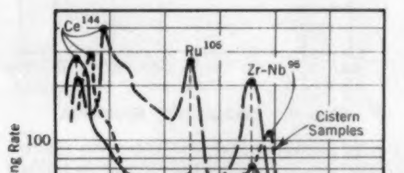

Fig. 5. Spectra of Environmental Samples

Samples are old and have relatively simple spectra.

a trace of zirconium-niobium 95. These findings are in reasonable agreement with the predicted abundances (*1*) which, at this age, show approximately 65 per cent of total activity due to the presence of cerium 144, about 6 per cent to cesium 137, about 5 per cent to ruthenium 106, and about 4 per cent to zirconium-niobium 95. The remaining activity is chiefly from promethium 147 and strontium 90 which do not emit gamma radiation. This spectrum does not show any peaks from induced activity.

The spectra of three relatively young environmental samples are shown in Fig. 7. One is for particulate matter in air and the other two are for the suspended and dissolved fractions of rainfall.

The air sample shows peaks due to cerium 141, iodine 131, ruthenium 103,

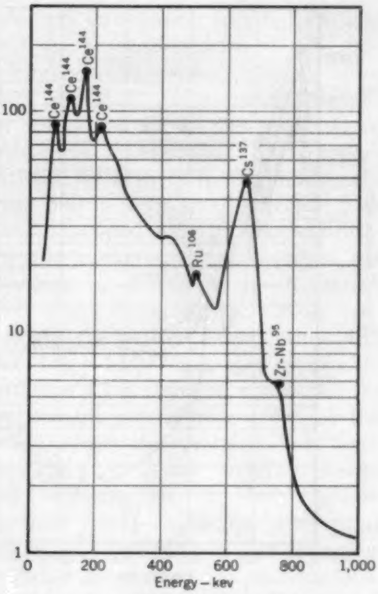

Fig. 6. Spectrum of Old Cistern Sludge Sample

Spectrum was obtained approximately 18 months after collection of sample.

zirconium-niobium 95, and lanthanum 140. The ruthenium 103 peak at about 500 kev probably includes some neodymium 147 (520 kev). The spectra of the rain samples, which, qualitatively, are very much alike, show a number of peaks characteristic of fission products of more recent origin. This observation is in accord with the gross beta decay of this material which indicates that it consists chiefly of fission products less than 1 week old. Two of the fission products of short half-life which can be readily identified are molybdenum 99 (with gamma energies of 740 kev and 180 kev) and its daughter, technetium 99*m* (gamma energy, 140 kev). Another parent-daughter pair of short half-life is tellurium 132 with a peak at 220 kev and iodine 132 with a gamma energy of 690 kev. Other peaks can be attributed to neodymium 147 plus ruthenium 103, to iodine 131, and to lanthanum 140. The cerium 141 activity is obscured by the low-energy molybdenum and technetium radiations and

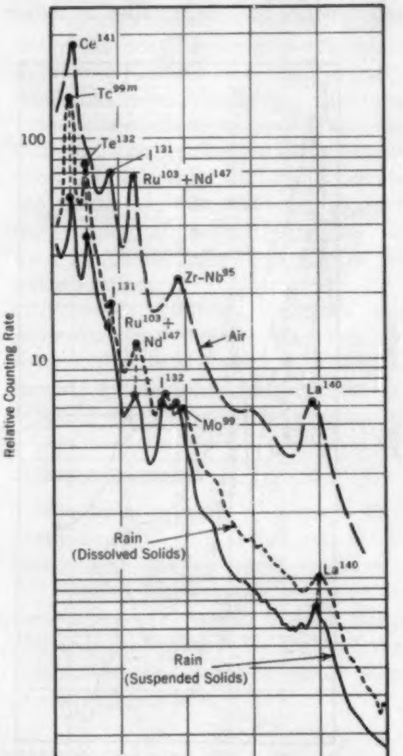

Fig. 7. Spectra for Young Environmental Samples

Fission products in rain samples are less than 1 week old.

the zirconium-niobium activity is masked by the iodine 132 and molybdenum 99 peaks.

Figure 8 illustrates a series of measurements made over a period of time on one of the rain samples included in Fig. 7. These curves show the disappearance of the short-lived isotopes molybdenum-technetium 99*m* and tellurium-iodine 132. Other isotopes of intermediate half-life, typified by iodine

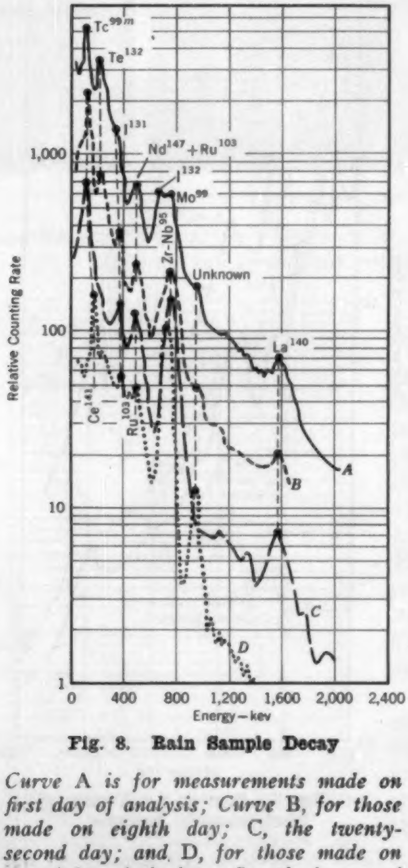

Fig. 8. Rain Sample Decay

Curve A *is for measurements made on first day of analysis; Curve* B, *for those made on eighth day;* C, *the twenty-second day; and* D, *for those made on the eighty-ninth day. Sample is one of those used for Fig. 7.*

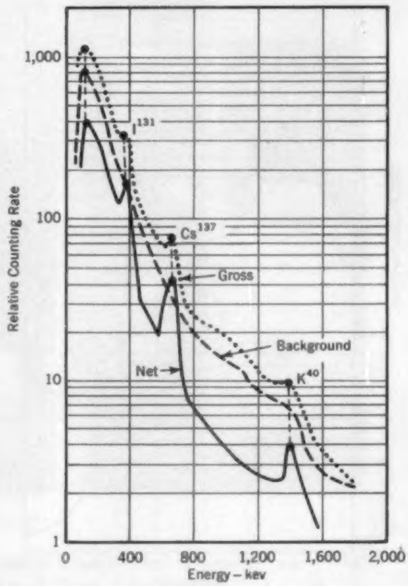

Fig. 9. Spectra for Milk and Instrument Background

Activity for milk represents very small increase over background activity.

131 and lanthanum 140, increase in prominence and then die out Finally, isotopes of longer half-life become the most prominent. Among these are zirconium-niobium 95 and the above-mentioned peak at 950 kev which was introduced by instrument malfunction. Two peaks, although remaining prominent throughout, have changed in nature. These are the low-energy peak at about 140 kev—initially largely due to molybdenum 99 and technetium 99*m* and finally due to cerium 141—and the peak at about 500 kev which changed from predominantly neodymium 147 to ruthenium 103. Where such mixtures occur chemical separations are needed for determination of the relative quantities involved although, sometimes,

sufficient information can be obtained from decay measurements.

Finally to be considered is the spectrum of Fig. 9. This curve, which is for milk, also shows the spectrum of instrument background. It is apparent that the activity in the milk represents only a very small increase over the background activity. By subtracting the background, however, a net spectrum is obtained which shows three peaks rather clearly. Most definite are the peaks due to cesium 137 and iodine 131; there is a reasonably certain identification of a peak due to the natural potassium content of the milk although the crystal used in these measurements is too small to detect this high-energy—1.6 Mev (million electron volts)—radiation with good efficiency. The peak at low energy is probably not due to any radioisotope, but is more likely a combination of the poor statistics caused by the high background in this region, of accumulation of the Compton effect, and of backscatter from the potassium, cesium, and iodine activities. From such a net curve, the quantitative determination of at least the cesium and iodine activities would be possible, provided the instrument was first calibrated with the individual isotopes and finally with mixtures of the two.

Summary

The principle on which gamma scintillation spectroscopy is based is the emission of a characteristic line spectrum of gamma radiation by a specific radionuclide. By the use of suitable instrumentation, one may obtain an actual spectrum with a peak at the characteristic gamma energy.

This discussion has shown the application of gamma spectroscopy as a qualitative tool in the identification of radionuclides in water and other environmental samples, especially as applied to the fission products. Decay measurements are often useful in confirming tentative identifications. Where further information is needed, quantitative data may be obtained—especially in relatively simple cases—if the equipment has been previously calibrated with radionuclides of known concentration. The qualitative data may be used as a guide for radiochemical separation or, alternatively, preliminary chemical separations may be used to obtain simplified spectra for quantification.

Although gamma detectors are somewhat less sensitive than beta detectors, this disadvantage is, to a great extent, nullified by the practicability of using very large initial samples.

Acknowledgment

The authors wish to express their gratitude to G. J. Karches and B. M. Branson of this laboratory for obtaining most of the spectra for this report and to S. A. Reynolds of Oak Ridge National Laboratory for helpful discussion in the identification of some of the radionuclides.

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Prevention and Control of Cross Connections at Oak Ridge, Tenn., Nuclear Plant

Gustave J. Angele

A paper presented on Mar. 21, 1958, under the sponsorship of AWWA, at the Engineer Joint Council's Nuclear Engineering and Science Congress, Chicago, Ill., by Gustave J. Angele, Plant San. Engr., Union Carbide Nuclear Co., Oak Ridge, Tenn.

PUBLICATIONS of many of engineering societies are replete with articles and papers relative to the means of supplying industrial plants and cities with a safe and sanitary water supply fit for human consumption.

In the vast number of publications and papers that are on record, however, very little mention is made concerning the methods of maintaining this water supply in its original condition in order that all workers may attain and maintain man's most precious possession—health.

To drink the mixture from a recently used water closet or to bathe in the waste liquids discharged from a urinal, the waste liquids of a radioactive laboratory, or waste of any other process is worse than disgusting. Such a condition may result, however, from the existence of a cross connection between a potable water system and a system conducting other liquids or gases which could contaminate the potable water system.

As defined by Babbitt and Doland (*1*): "A cross connection is any physical connection, either direct or indirect, that will permit or may possibly permit the flow of nonpotable water into a conduit or receptacle containing potable water." A direct connection consists of a continuous conduit leading nonpotable water into the potable water supply. An indirect cross connection consists of a gap or space across which nonpotable water may fall or be sucked, blown, or otherwise made to enter the potable water supply.

For the purpose of this article, process water is considered as any water that is used for purposes other than drinking and washing or as a source of supply to safety showers and eyewash fountains. Raw water is the water which is pumped from the river and not treated prior to use.

The primary objective of every sanitary engineer employed in an industrial plant, be it nuclear or otherwise, should be to preserve the health of his fellow workers by the elimination of and the prevention of cross connections, in order to maintain a safe and sanitary water supply that is fit for human consumption.

In any plant the size of the Union Carbide Nuclear Co. installation at Oak Ridge, Tenn., the possibility of cross connections, both direct and indirect, is apparent. With numerous laboratories and process operations continuing throughout the years, and new developments being made in the laboratories, some method of eliminating and preventing cross connections must be placed in effect.

It is the author's purpose to discuss some of the possible and probable ways that cross connections can occur, if adequate and frequent checks are not made during new installations and alteration work, in any plant, regardless of its size or operation. This article will also discuss the necessary steps that have been taken in the Y-12 Plant of Union Carbide Nuclear Co. at Oak Ridge, Tenn., to prevent and control cross connections.

Background

A brief history of the Y-12 Plant will provide some idea of the problems involved. In 1943, when the atomic bomb was first conceived, The Manhattan District engineers awarded a contract to the Stone and Webster Engineering Company to construct the Y-12 Plant, which was to produce the necessary material for these bombs. This plant was known as the Electromagnetic Separation Plant, and consisted of approximately 170 buildings with a floor area of approximately 4,500,000 sq ft. The original plant area covered approximately 500 acres, and new water supply mains, sewers, and other facilities were required during its construction. At the peak of construction a force of 13,000 men were employed, and during peak production 22,000 were employed for production and maintenance operation. The combined peak raw- and filtered-water usage, when the plant was in full operation during World War II, was estimated to be approximately 23.5 mgd.

For construction and operation of this plant, Stone and Webster Engineering Co. had provided separate facilities for both process and domestic filtered-water services. Often, raw water was used as the makeup supply for the cooling towers, and cooling-tower water was recirculated through heat exchangers in the production areas of the plant. Filtered (potable) water was used primarily for drinking, shower facilities in changehouses, wash basins, water closet flushing, steam production, and cooking in the cafeterias.

With the conclusion of hostilities, however, the Y-12 Plant was placed in standby condition. It was during this period that Union Carbide Nuclear Co. took over the operation of the plant from the Tennessee Eastman Corp. In the ensuing years, new operations were conceived for the plant, most of the electromagnetic equipment was removed from the buildings and new processes were installed.

During the installation of new processes, repeated surveys were conducted and all drawings of the responsible architect engineers were reviewed to determine if any cross connections, both direct and indirect, were probable or apparent. Due to the results of the surveys and the necessary full-time work required to check new installations, the position of sanitary engineer was established on a full-time basis. Prior to the establishment of the position of sanitary engineer, the author was the supervising engineer in charge of piping design in the plant, and as such, he had reviewed all design work relative to the filtered water and sanitary sewer systems originating in the piping design section of the engineering department. Therefore, he was chosen to serve the plant as its full-time sanitary engineer.

It would be well at this point to mention a situation where the lack of constant surveillance of the water systems can cause serious trouble. This was a polio epidemic in 1952 at Huskerville, Neb., which Paul Bancroft,

associate professor of pediatrics, and Warren E. Englehard, associate professor of bacteriology, at the University of Nebraska, attributed to the removal of vacuum breakers from the water closets (*2*). In a section of the report of this incident, it was explained that originally all of the water closets were equipped with automatic flush valves and vacuum breakers. In the course of years, prior to the epidemic, repairmen had removed faulty flush valves and vacuum breakers and installed new flush valves without the vacuum breakers. The elimination of the vacuum breakers established a cross connection between the toilet bowl and the filtered-water supply.

Potential Cross Connections

Two direct connections that possibly could occur in any process systems are shown in Fig. 1. In Fig. 1a, a storage tank is to be filled with a solution of nitric acid and water so the two supplies are connected together with control valves and check valves. It will be noted that the connection is made to the supply of the safety shower, as it is the nearest filtered-water supply. In Fig. 1b, the filtered water is to be used to wash process material the level of which is well above the outlet to the wash basin, and as the material may be heavier than the water, there is a possibility of backing the material to the basin. Additional direct connections could occur between the filtered-water system and the steam, compressed-air, and recirculated tower water systems.

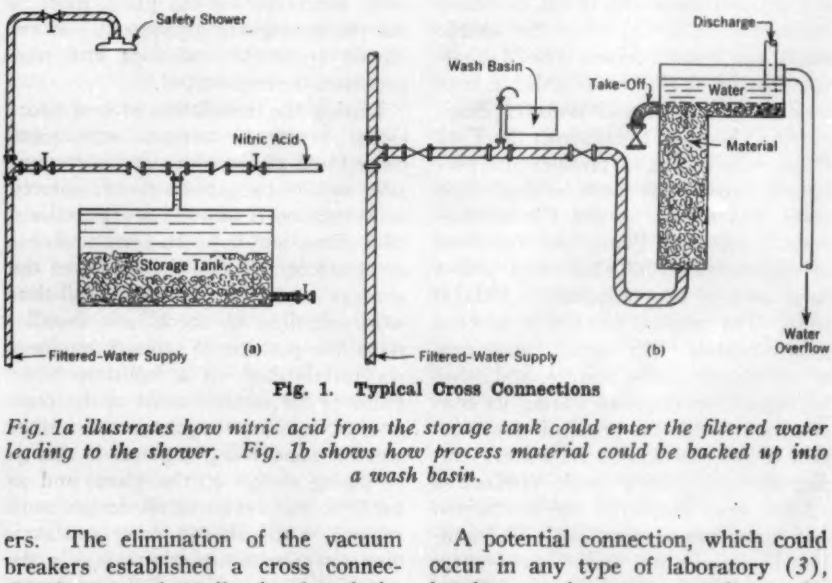

Fig. 1. Typical Cross Connections

Fig. 1a illustrates how nitric acid from the storage tank could enter the filtered water leading to the shower. Fig. 1b shows how process material could be backed up into a wash basin.

A potential connection, which could occur in any type of laboratory (*3*), involves a hose connected to the filtered-water supply and left lying in a bacteriological laboratory sink where contaminated cultures are present. During periods of low pressure, a vacuum can form at the spot where the faucet supply joins the main water line. When water is drawn nearby, the hose can act as a siphon, drawing the germ-laden water into the supply line. Then, when water is drawn from else-

where in the building, such as the upper floors, the contaminated water flows there also. This situation is particularly likely to occur if pressures are low and mains are of inadequate size. This condition can be corrected by installing a vacuum breaker at the faucet.

Another potential connection arose from an automatic pipet washer, which was to be installed in a laboratory. This washer consisted of a vertical upright cylinder approximately 6 in. in diameter, with a wire basket inside. Inside the basket approximately ten to fifteen pipets were to be placed, to be washed by an automatic arrangement that was to be connected to the filtered-water line, also serving a drinking-water cooler. The pipet washer would fill to approximately 2 in. from the top and, by means of siphon action, empty itself and then refill again. This washer was to be located on a shelf approximately 2 ft higher than the drinking fountain. On inquiring as to the probable contents of the pipets, the author was informed that they would contain low-level activity canine urine and that the laboratory technician had fabricated the device from an article that he had read in a recent trade journal. The publication had neglected to advise, however, that a suitable vacuum breaker should be installed in the supply line. This connection was later installed, but the filtered-water system was protected by connecting the water supply of the automatic washer at a point approximately 12 in. higher than the top of the washer and adding a ½-in. vacuum breaker on the supply line.

Prevention Program

The policy adopted by the plant management at Oak Ridge specifies that no connection can be made to any filtered-water line without the approval of the sanitary engineer. All engineering drawings, either made by plant personnel or outside contractors, must be approved by the sanitary engineer if they are concerned with the filtered-water system, sanitary sewer system, storm sewer system, or industrial waste systems. In addition, if a small job order is written, the sanitary engineer investigates the job to be performed at the request of the originator and issues a permit for the installation before the maintenance personnel can proceed with the work.

At the present time, it is the responsibility of the operations department requesting an installation to prepare a written order and at the same time request the sanitary engineer to investigate and issue a permit for the installation. If, in the judgment of the sanitary engineer, this work should pass through the engineering department, he will so advise the requester, and the work is designed by the engineering department and then approved by the sanitary engineer, prior to its being sent to the field for installation. If, in the judgment of the sanitary engineer, the job can be performed by the issuance of a permit, he prepares the permit and sketch and it is distributed as indicated at the bottom of the permit. In this way, the engineering department can be kept informed of any changes that are occurring in the plant and can correct its drawings.

When the work is completed in the field, the maintenance department informs the sanitary engineer that the work is ready for his inspection. In this manner, all completed work on permits is reviewed prior to being placed in service. If the work is of a major nature, a copy of the work order is sent to the sanitary engineer so that he can be kept informed of all future

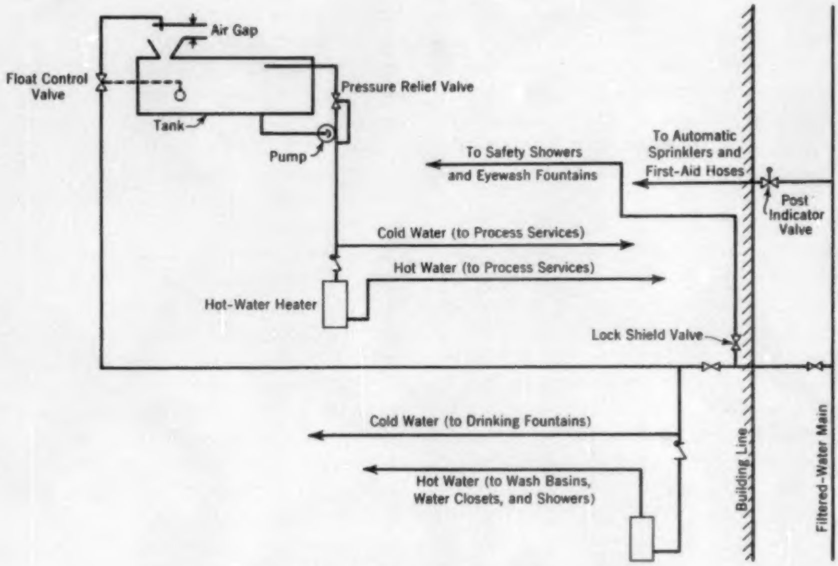

Fig. 2. Water System Utilizing Tank and Pump

The diagram illustrates an earlier type of water system installed in the Y-12 plant at Oak Ridge, Tenn.

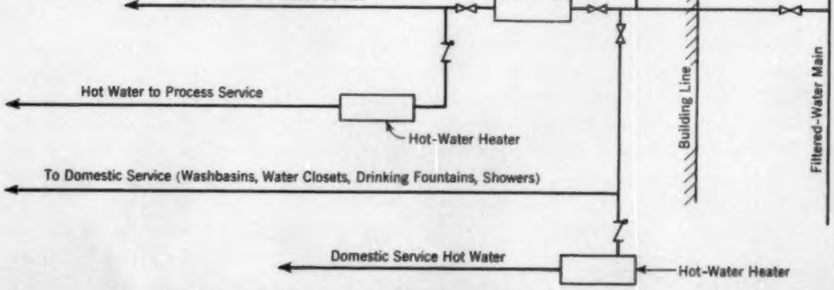

Fig. 3. Water System Utilizing Backflow Preventer

This system eliminates the necessity for a roof tank and electrical power.

work and prepare himself for review of the drawings. All drawings connected with changes to the water systems, sanitary and storm sewers, and industrial waste systems must be reviewed and approved by the sanitary engineer prior to being sent to the field for construction.

In addition to these duties, the sanitary engineer is also kept informed of the results of water sampling throughout the plant. When the plate count on any sample is greater than zero, a thorough investigation is made of the offending location to determine the cause. In the meantime, the unit is put out of service and is resampled until the plant count drops to zero on two successive days.

Another duty of the sanitary engineer is conducting educational programs for plant personnel. This educational program consists of presentation of slides of the typical types of cross connections and any new or unusual connections that are found during surveys. The personnel of the plant are encouraged to report any connection that they think might become a potential hazard to plant personnel. These educational programs average about two a month, and are of approximately 1-hr duration.

The first step taken to prevent possible future cross connections was to write into all design criteria the requirement that separate water systems must be provided for all process buildings. The first system installed consisted of tanks mounted on the highest point of the building that the system was to serve. A diagrammatic picture of one of these systems is shown in Fig. 2. These tanks were supplied from the filtered-water system to the building and the level of the water in the tank was controlled by float operated valves. The first systems were of the gravity type, and no pump was installed in the discharge from the tank. After a short period of time, however, new processes were installed that required higher pressures than were possible to obtain with the gravity type of system. With this in mind, circulating pumps, together with suitable valves, were added to the process water system. If there is no demand for process water, the circulating pump discharges back to the tank.

More recently a second type of process water system has been designed as shown in Fig. 3. This system utilizes a differential backflow preventer and does away with the tank and pump. The system has proved to be the most acceptable, due to the fact that it is not necessary to install a tank on the roof of a building, as often the installation of such a tank would require additional strengthening of the building structure. Also, a failure of electricity would not take the system out of service, because no electrical power is required. It will be noted that in both systems the domestic service and the safety shower service is connected ahead of the process water systems. Also, any one of the systems can be taken out of service without shutting down either of the other two. It will be noted that domestic filtered water is connected to the supply main at the point where the filtered water enters the building. Safety showers and eyewash fountains are supplied independently of the domestic water supply, and a lock shield valve or a locked valve protects these vital services. This method was used for the installation of several rehabilitated buildings and was found very successful.

Backflow Preventer Operation

The operation of the differential backflow preventer is as follows (Fig. 4): The backflow preventer includes two check valves, *A* and *B*. During flow of water in normal direction and at cessation of normal flow, spring-loaded Check Valve *A* automatically acts to give a reduction in pressure. Regardless of the supply pressure, the pressure between the two check valves is less than that in the supply side.

For the purposes of illustration, assume the inlet pressure to be 60 psi and assume that no water is being withdrawn from the domestic lines supplied by the device. Under this condition Valve *A* reduces the pressure to approximately 52 psi which will then be the pressure prevailing throughout the process piping area, as well as between Valves *A* and *B*.

As mentioned above, the pressure differential relief valve automatically operates to maintain the lower pressure that has been established by Valve *A*. This is accomplished as follows: Under normal flow and at cessation of normal flow, the pressure reduction set up by Valve *A* is sufficient to cause the relief valve to remain closed, and it will continue to remain closed as long as the pressure behind Valve *A* remains approximately 8 psi less than the pressure ahead of Valve *A*.

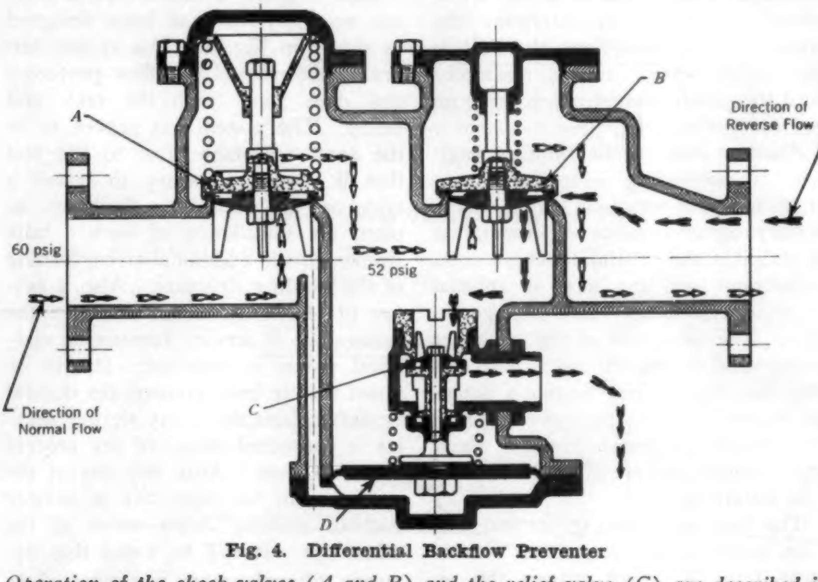

Fig. 4. Differential Backflow Preventer

Operation of the check valves (A and B) and the relief valve (C) are described in the text.

Check Valve *B* is lightly spring loaded to a closed position and offers practically no pressure loss. Its principal function is to prevent the unnecessary draining of the consumer's system through the diaphragm-operated pressure differential relief valve (*C* in Fig. 4) between Valves *A* and *B*, in the event that a substantial pressure drop should occur in the supply line.

Two conditions can upset this balance. A drop in the supply line would cause an equal drop in the area under the diaphragm (*D*). When the pressure differential across the diaphragm decreases to 4 psi, the relief valve would automatically open and drain to atmosphere just enough water to maintain the pressure between the check valves 4 psi lower than on the upstream side of Check Valve *A*. This would continue as long as the supply pressure continued to drop. An increase in pressure in the domestic piping system past Check Valve *B* would also produce a similar action if Valve *B* should be leaking. In this event, a higher pressure would build up against the upper side of the diaphragm, and when the pressure against the checks came within 4 psi of the pressure on the upstream side of *A*, Relief Valve *C* would automatically open and drain to atmosphere as described above. Maintaining this zone of low pressure makes it impossible for backflow or back siphonage to take place, because water cannot flow from a region of low pressure to a region of higher pressure.

Visual indication of failure of any part vital to the prevention of backflow is easily observed by water draining continuously from the relief valve. If this occurs while water is flowing through the valve, it indicates a foreign substance under the relief valve seat. If it occurs only when no water is being withdrawn from the domestic side, it indicates that Check Valve *A* is leaking and therefore not maintaining the zone of reduced pressure. Leakage from the drain valve would also occur if the diaphragm were to rupture, or if the spring used to load Valve *A* were to break.

Tests on Backflow Preventers

During the semiannual inspection of the backflow preventers, several tests are conducted (Fig. 5): The backflow preventer is working properly if all of the following conditions are true:

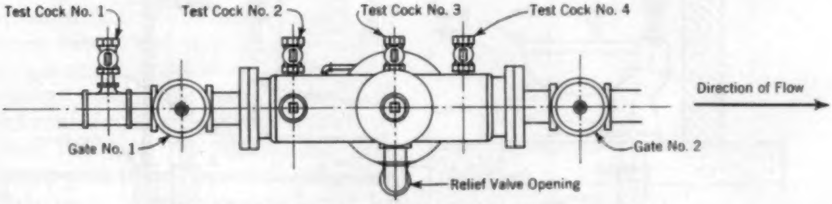

Fig. 5. Apparatus for Testing Backflow Preventer

Operation and purpose of the two gate valves and the four test cocks are described in the text.

1. There is no discharge from the relief valve opening when water is flowing through the device in the normal direction. No discharge under this test indicates that there is no foreign material under Valve *C*.

2. There is no continual discharge from the relief valve opening when only gate valve No. 2 (Fig. 5) is closed. (Intermittent discharge may occur if there are pulsations in the supply pressure, but this is normal operation.) This test indicates that the first check valve (*A*, Fig. 4) is tight.

3. The relief valve opens to discharge water and maintains the pres-

sure at test cock No. 3 at least 2 psi below the pressure at test cock No. 2, when pressure is brought through a hose from test cock No. 2 into test cock No. 3.

4. With gate valve No. 2 closed, there is no discharge from the relief valve when pressure is brought from test cock No. 2 through a hose into test cock No. 4. Drainage from the relief valve under this test would indicate that the second check valve (*B*, Fig. 4) is leaking.

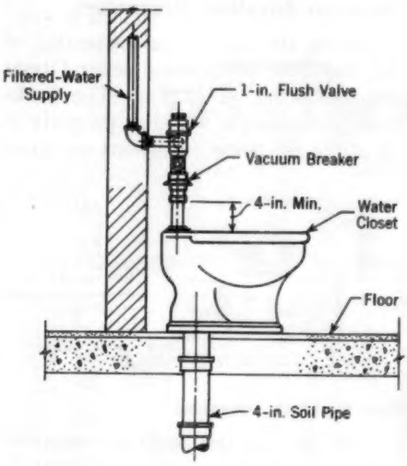

Fig. 6. Vacuum Breaker Installed on Water Closet

The minimum distance between the vacuum breaker and the fixture flood level is 4 in.

The backflow preventer is not working properly if any of the following conditions are true:

1. There is continual discharge from the relief valve (*C*, Fig. 4) when water is flowing through the device in the normal direction. Discharge under this condition indicates presence of foreign material under the relief valve seats.

2 There is continual discharge from the Relief Valve *C* when gate valve No. 2 is closed. Discharge under this condition indicates foreign material under the seat of the first check valve (*A*).

3. There is no discharge from the relief valve when pressure is brought from test cock No. 2 through a hose

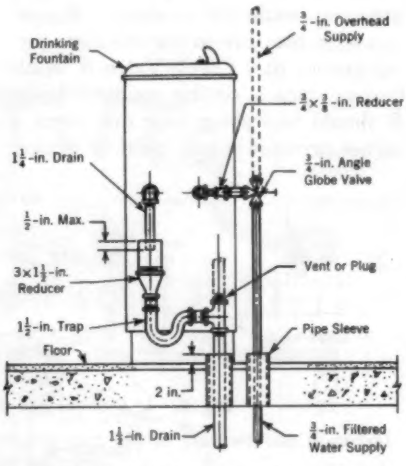

Fig. 7. Installation of Drinking-Water Cooler

This method of installation utilizes the open funnel and trap arrangement.

into test cock No. 3. Under this condition, the relief valve should open and discharge water and maintain the pressure (at test cock No. 3, 2 psi below the pressure at test cock No. 2.

4. There is discharge from the relief valve when pressure is brought from test cock No. 2 through a hose into test cock No. 4. Drainage from the relief valve indicates that the second check valve (*B*) is leaking.

Standards for Equipment

In order to standardize the installation of vacuum breakers and other equipment throughout the plant, several standards have been prepared for use.

Figure 6 indicates the approved method of installation of a vacuum breaker on all water closets throughout the plant. It will be noted that the critical level of the vacuum breaker is a minimum of 4 in. above the flood rim of the fixture. Two types of vacuum breakers are used on water closets in the plant: the rubber sleeve type, and the swinging-seat type.

There is also an approved method of installing drinking-water coolers throughout the plant (Fig. 7). Some question has been raised relative to the open funnel and trap arrangement of this method. On some of the older coolers used in the plant, however, no internal traps are provided. Therefore, the open-trap method has been adopted, as there is one less connection to be made when removing a cooler for servicing.

Figure 8 shows the open-sight flow and air gap used on certain types of equipment, in which the air gap is controlled by the removal of the lower pipe nipple from the coupling.

Additional standards are being developed for use throughout the plant and will be added from time to time.

Several types of vacuum breakers have been approved and are stocked for use throughout the plant. One is a small vacuum breaker unit in the $\frac{3}{4}$ in. size,* which has found wide use throughout the plant in laboratories where it has been inadvisable to install separate process water systems. These laboratories are generally in isolated areas, and the cost of providing separate water systems would be prohibitive. This breaker is similar to the rubber sleeve type used on the water closets, with the exception that a small brass insert has been added to prevent the rubber sleeve from expanding and closing the air openings.

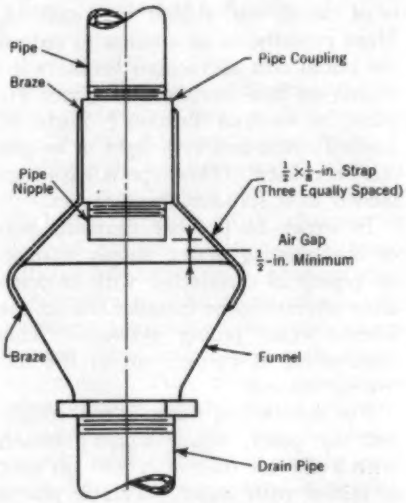

Fig. 8. Drain Funnel Installation

When the open-sight flow funnel is used, the air gap is controlled by manipulation of the pipe nipple.

Another type,† selected for use in the $\frac{1}{2}$ in. and $\frac{3}{4}$ in. sizes, has its plunger made of heat resisting plastic. A further adaptation of this type of vacuum breaker is used in a combination faucet ‡ that has been adapted for use

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* The Ormax vacuum breaker, manufactured by the Kewaunee Mfg. Co., Adrian, Mich.

† Model V-300-A, manufactured by the Sloan Valve Co., Chicago, Ill.

‡ Model No. HB-15309, of the American Radiation & Sanitary Corp., Pittsburgh, Pa.

on laboratory sinks. This unit has an advantage in that the center-to-center dimensions of the supplies are the same as those of a regulation combination faucet. Recently, another adaptation has been used on a piece of equipment that required a 3-in. vacuum breaker. The particular type used * is made in sizes through 4 in., and the plunger is of metal with rubber cup washers. More recently, in an attempt to reduce the initial cost of vacuum breakers installed on hose outlets throughout the plant, a vacuum breaker † made of molded nylon and very light in weight has been used. This type is easily attached to a standard hose faucet.

In order to prevent contamination of the existing water supply system, all piping is disinfected with chlorine after alterations or installations on the filtered-water piping systems. This disinfecting is carried out in the following manner:

For disinfecting water lines throughout the plant, liquid laundry bleach with a chlorine content of 5.25 per cent is mixed with water. This is placed in the piping systems and retained for a period of 8 hr. The general mixture is approximately 200 ppm. After the mixture has been left in the new work for the proper length of time, the lines are flushed for approximately 1 hr, and a chlorine residual test is made by the sanitary engineer, to determine if the chlorine residual is the same as the water throughout the rest of the plant. If the new piping work is connected to either a drinking water cooler or to any other facility where drinking water could be obtained by the plant personnel, the health physics department is notified and they take water samples of the outlets of the system until such time as the samples show a zero plate count on two successive days. When this condition is reached, the new system is placed in service.

* Model E-1 of the Bidoro Mfg. Co., Huntington Station, N.Y.

† Manufactured by the Hercules Plastic Corp., New York, N.Y.

Conclusion

Periodic surveys are made of the entire plant to determine if any additional connections have been made without proper authorization. If so, the attention of the operating personnel is called to these unauthorized connections, and correction is requested at once.

It is the feeling of management of the Union Carbide Y-12 Plant that it has a good program for the prevention and control of cross connections, but officials realize that only eternal vigilance will keep the filtered water suitable and safe for human consumption.

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Variable-Speed Control as Applied to Water Pumping

Marvin H. Owen

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Marvin H. Owen, Sr. Mech. Engr., Dept. of Water & Power, Los Angeles, Calif.

FOR years the double-suction, horizontal, centrifugal pump, driven by a squirrel-cage induction motor, has become the standard unit for water utility service. It is still the best selection for the great majority of installations. It is the unusual in a water system, however, that causes consternation.

When a pump operator finds it necessary to throttle his pump discharge because the pressure is required to remain below a certain value, he begins to wonder if the designer would not be fulfilling his duties more efficiently by some other method. This is especially true if the operator has seen some of the textbooks used in hydraulics courses, which show the differences in efficiency between throttling the pump discharge and changing the pump speed.

Before any consideration is given to the method of controlling the discharge pressure, however, the first question to be answered would be: Is the control of the discharge pressure really necessary? If the pressure limits are imposed by faulty conditions of the discharge lines, then it might be better to replace the weak section of pipe, because it would have to be replaced eventually at any rate.

If it is ascertained that there are other facets over which there are no simple controls for placing a limiting value on the discharge pressure, the plant designer is faced with a number of different solutions to the problem.

Where the suction pressure does not vary, it may be possible to limit the discharge pressure with changes in demand by the selection of a pump with comparative flat head-capacity characteristics. In other words, the discharge pressure of the pump varies comparatively little over a wide capacity range. For those installations where there is a widely fluctuating suction pressure or where a flat head-capacity type of pump cannot be used and where pressure control is needed, there are two bases of control—throttling the pump discharge or varying the speed of the pump. The disadvantages of the throttling process for controlling the discharge pressure are that energy is wasted when operating while throttled and greater maintenance is required on the discharge valve.

Selection of Equipment

There are many ways by which variable-speed control can be accomplished, and each method has its advantages and disadvantages. Before any selection can be made, the following information is necessary: [1] the range of head which must be controlled; [2] the amount of time in

TABLE 1

*Costs for Various Methods of Variable-Speed Drives and Throttling Control**

Flow *gpm*	Type of Pressure Control	Dis-charge Head *ft*	Pump Efficiency *per cent*	Motor Efficiency *per cent*	Drive Efficiency *per cent*	Input to Motor *hp*	Excess Over Lowest Method *hp*	Excess Cost† *cents/hr*	Excess Energy Costs—*$/year*: 2,500 hr Wide Open	5,000 hr Reduced flow	Total	5,000 hr Wide Open	2,500 hr Reduced flow	Total
	Problem: To Maintain 110-ft Head at All Times at a Maximum Flow of 2,800 gpm With a 100-hp Unit													
2,800	Throttling	110	79	92	—	85	—	—	—	—	—	—	—	—
	Wound rotor	110	79	88	—	89	4	3	—	—	—	—	—	—
	Variable-speed coupling	110	79	92	95	89	4	3	—	—	—	—	—	—
2,000	Throttling	140	86	92	—	90	13	10	—	500	500	—	250	250
	Wound rotor	110	87	80	—	80	3	2	75	100	175	150	50	200
	Variable-speed coupling	110	87	92	90	77	—	—	75	—	75	150	—	150
1,500	Throttling	148	80	91	—	77	13	10	—	500	500	—	250	250
	Wound rotor	110	83	75	—	67	3	2	75	100	175	150	50	200
	Variable-speed coupling	110	83	89	88	64	—	—	75	—	75	150	—	150
1,000	Throttling	155	65	89	—	68	18	13	—	650	650	—	325	325
	Wound rotor	110	72	73	—	53	3	2	75	100	175	150	50	200
	Variable-speed coupling	110	72	89	87	50	—	—	75	—	75	150	—	150
	Problem: To Maintain 145-ft Head at All Times at a Maximum Flow of 4,500 gpm With a 200-hp Unit													
4,500	Throttling	145	83	92	—	216	—	—	—	—	—	—	—	—
	Wound rotor	145	83	92	—	216	—	—	—	—	—	—	—	—
	Variable-speed coupling	145	83	92	95	227	11	8	—	—	—	—	—	—
3,000	Throttling	180	83	92	—	178	22	15	—	750	750	—	375	375
	Wound rotor	145	84	84	—	156	—	—	—	—	0	—	—	0
	Variable-speed coupling	145	84	92	90	158	2	2	200	100	300	400	50	450
2,000	Throttling	192	68	92	—	155	31	23	—	575	573	—	1,150	1,150
	Wound rotor	145	74	80	—	124	—	—	—	—	0	—	—	0
	Variable-speed coupling	145	74	91	88	124	—	—	200	—	200	400	—	400
1,000	Throttling	198	46	90	—	121	27	20	—	1,000	1,000	—	500	500
	Wound rotor	145	50	67	—	95	1	1	—	50	50	—	25	25
	Variable-speed coupling	145	50	90	87	94	—	—	200	—	200	400	—	400

* The approximate excess cost of a wound-rotor motor over a standard induction motor is $2,000; of a variable-speed coupling, $2,500. The yearly charge to equal equipment costs is based on an interest rate pf 4 per cent, a life of 25 years, and tables for present value of 1 per cent per year; would-rotor motors $128 per year, and variable-speed coupling $160 per year. Excess energy costs over the lowest energy cost for the particular flow conditions are considered. For example, in the 100-hp unit at wide open, wound rotor costs 3 cent per hour more than the lowest method (throttling) and at 2,000 gpm flow costs 2 cents per hour more than the variable-speed coupling.

† Cost of energy figured at 1 cent per kilowatt-hour.

which the unit operates below its peak efficiency discharge condition; [3] the minimum amount of water which is required to be pumped; [4] the cost of energy; and [5] the capital cost of whatever equipment is required.

After this information is evaluated, the method of driving the pump can be considered. The types of drivers in common usage are: the internal-combustion engine, the direct-current motor, the alternating-current wound-rotor motor, the use of a magnetic coupling or hydraulic coupling in conjunction with an a-c squirrel-cage induction or synchronous motor, and the multiple-winding a-c induction motor.

The use of internal-combustion–engine drives for centrifugal pumps requires a greater investment, greater maintenance cost, and greater energy cost than does a standard electric motor. Where no electric energy is available, however, or for emergency purposes, the internal-combustion engine drive is ideally suited.

The disadvantages of the direct-current motor drives are that d-c energy is seldom available on public utility power lines, and the use of a motor generator set involves a large capital investment, as well as the continuous losses in the transformation from alternating- to direct-current itself.

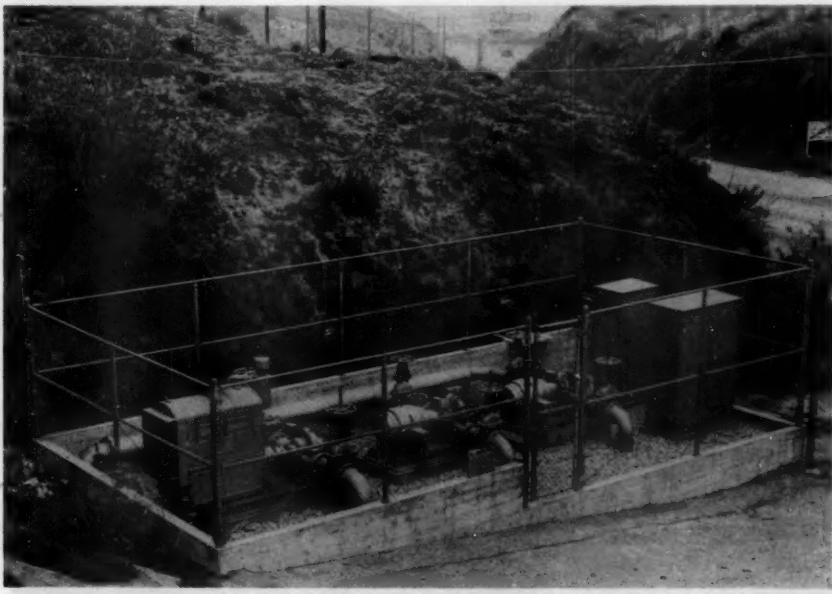

Fig. 1. Baldwin Hills Pumping Station

This system is designed to draw upon a second source of water in periods of high demand.

The hydraulic variable-speed coupling and the magnetic variable-speed coupling both involve extra capital expenses and the continuous energy

losses in the couplings themselves, regardless of the speed at which the unit is run. This type of drive is worthy of consideration where extreme water hammer problems are present, but that is beyond the scope of this article.

The a-c wound-rotor motor requires a high capital expense, a loss in efficiency at reduced speeds, with the speed changes being in definite steps. The expensive control system required puts this type of drive at a great disadvantage except in extreme situations. Wound-rotor motors are used in several of the eastern cities, where only limited elevated storage is available and where a system must be held under constant head regardless of demand. In the West this practice is not used to any extent.

The dual-winding induction motor requires a greater capital investment than the squirrel-cage motor, and provides only the two speeds. With this type of unit, however, the efficiency is practically the same at the low speed as at the high speed. In addition, the problem of automatic control can be simplified.

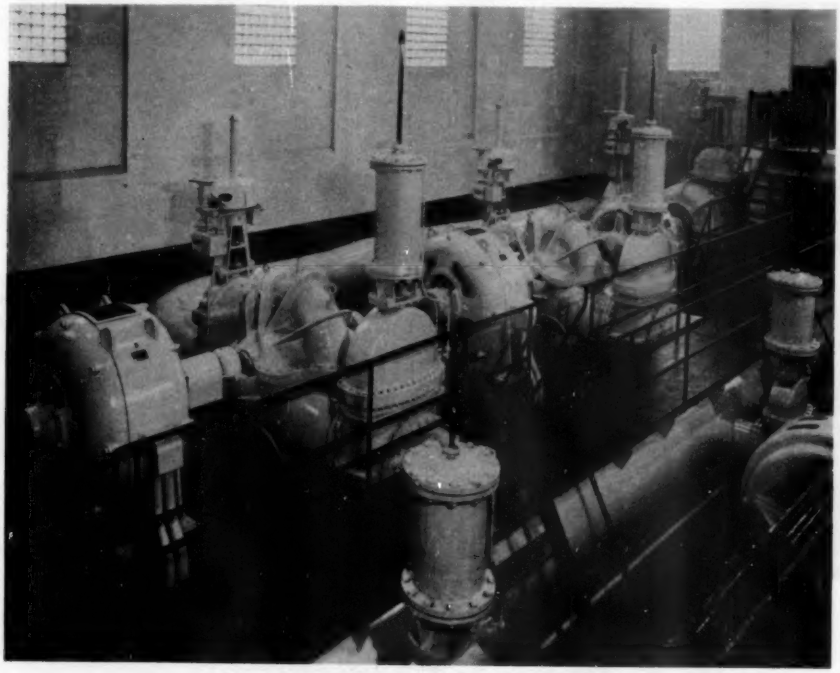

Fig. 2. Fletcher Drive Pumping Station

Shown above are the dual-winding units discussed in the text.

Possible Solutions

In order to present some of the possible solutions to the selection of equipment, two case studies have been set up. The first study is of a 100-hp pumping unit with a speed of 1,760

rpm, and a normal operating capacity of 2,800 gpm at 110-ft head. The maximum line pressure must be maintained at 110 ft. The second example is a 200-hp pumping unit with a speed of 1,760 rpm and a normal operating capacity of 4,500 gpm at a head of 145 ft.

Table 1 shows the comparisons in energy costs and purchasing costs between operating a standard squirrel-cage induction motor–driven pump using the throttling method, the wound-rotor motor–driven unit, and a variable-speed coupling used to couple the standard induction motor to the pump.

To illustrate the manner by which the various factors can affect the choice of units, study indicates the 100-hp unit would operate 2,500 hr per year at the designed flow of 2,800 gpm, and for 5,000 hours with the flow reduced to 2,000 gpm. The excess cost of the throttling system over the wound-rotor motor is $325 per year, which is more than the $128 break-even point for the extra equipment involved. With the same operating conditions, the variable-speed coupling would save $425 per year excess energy cost. The choice, then, would be the variable-speed coupling drive. If the unit were to be operated for 5,000 hr per year at 2,800 gpm and 2,500 hr at the 2,000-gpm point, however, the excess cost of energy for the wound-rotor motor is only $50 per year, and for the variable-speed coupling drive, the saving is $100 per year. Neither sum exceeds the cost of the extra equipment, so for this operation, the standard induction motor directly connected to the centrifugal pump is the most economical.

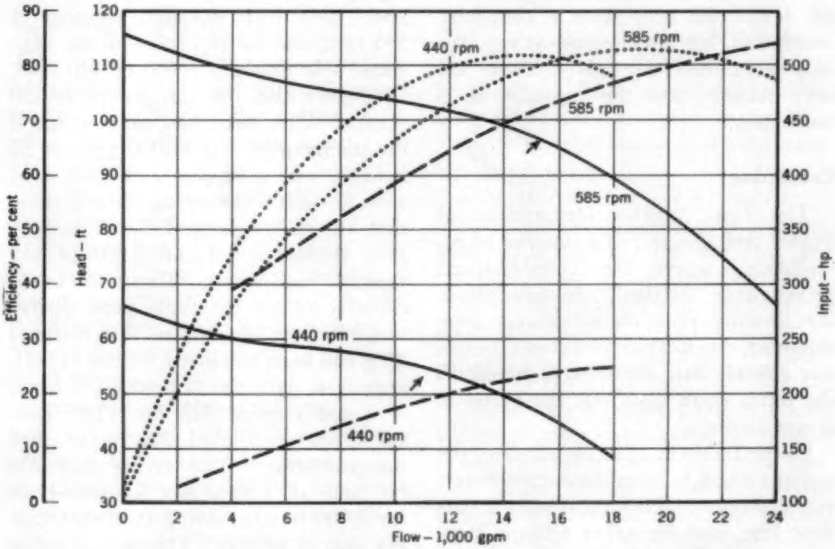

Fig. 3. Variable-Speed Operation at Fletcher Drive Pumping Station

Solid lines indicate head capacity; dashed lines, input to motor; and dotted lines, overall efficiency, for the two units, as labeled. Arrows refer to operating conditions described in the text.

In the second situation, for the 200-hp unit, the wound-rotor motor is the most economical if there are more than 2,200 hr of throttling operation per year. If there were a single large change in suction pressure or in demand, a dual-winding induction motor could be used.

From an economic standpoint, where more than a single-speed control is desirable, the dual-wound induction motor will often be the most economical device not only from a simplicity standpoint, but also because it requires only simplified controls. They are very reliable, and the capital cost is much less.

Examples

The Los Angeles Department of Water and Power has a number of installations where the variable-speed drives were installed. In two places the limiting pressure conditions were removed, due to system changes, before any reliable data could be obtained, so the extra costs were not recovered in power savings.

In the Baldwin Hills installation, the pump suction is taken from two different sources—one from a reservoir outflow line, and the other from a large main (Fig. 1). The pump suction is piped in such a manner that the suction is taken from the line having the highest head. By using a simple mercoid switch, the change in pole selection is accomplished.

In normal operation, the low-speed windings are used with an accompanying saving and power cost to utilize the high suction head. In periods of high demand, as experienced in the summer months, however, the suction head varies a great deal, and the reservoir connection is utilized for approximately 22 per cent of the total running time. This system has proved extremely reliable and has been a considerable savings over the proposed wound-rotor motor layout that was made before this plant was installed.

In another plant, however, the Fletcher Drive station, there are two units which are driven by two-speed dual-winding induction motors (Fig. 2). In this situation the two sets of windings have twelve poles on the high-speed side with the unit running at 585 rpm, and sixteen poles on the low-speed side giving a speed of 440 rpm. On high speed, the unit pumps 15,350 gpm at 97 ft head and on low speed the pumping rate is 11,000 gpm at 53 ft head, with a supply head fairly constant at 63 ft. Operating records show that the unit operated 5,000 hr per year on low speed and 2,800 hr per year on high speed. Using the head-capacity curve for high-speed operation (Fig. 3), it is noted that if throttling had been employed for the 11,000-gpm flow with the desired 53-ft head, it would require 405 hp. The low-speed operation used 204 hp to meet this condition. The saving was 201 hp, and at 1 cent per kilowatt-hour for 5,000 hr, the saving in energy cost per year is $7,500. This is equivalent to spending some $117,000 for additional equipment, and, of course, the cost of the dual-winding feature did not approach this figure.

Thus, it can be seen that each installation requires individual study, and all of the types of operation should be considered before any decision is reached. There is no simple formula to cover all situations and no guarantee that the operating conditions first assumed will not change; much still depends on whether the designer was fortunate in making necessary choices.

Low-Cost Automation for Water Treatment and Pumping Plants

William E. Hooper

A paper presented on Oct. 23, 1957, at the Alabama-Mississippi Section Meeting, Biloxi, Miss., by William E. Hooper, Mgr., Power, Water & Gas Dept., Sheffield, Ala.

A SUBSTANTIAL degree of highly reliable automation can be applied to a conventional water treatment and pumping plant at a price within the financial means of most plants.

Since July 1956, the Sheffield, Ala., plant has operated automatically its raw-water pump, its prefiltration chlorine feeder, alum feeder, filters, lime feeder, postfiltration chlorine feeder, fluoride feeder, and high-lift pumps. The plant operates without an operator for 8-hr periods.

Since the invention of the wheel, man has moved toward reducing the effort of his muscles in getting what he wants. He has reached the point where relatively little physical effort is required to produce and to put into place those things he finds desirable. Now he has turned his attention also to reducing the effort of his mind in getting what he wants. For his muscles there is mechanization and for his mind there is what has become known as automation.

Long before the wheel, man began mechanization of his water supply when he first used a shell to dip up his drink of water. Although the water supply field has, perhaps, kept pace in mechanization, in automation the field is lagging, despite the fact that water is the easiest of all materials to handle. Apparently, ease of handling is offset by another characteristic of water as found in nature—namely, in complicated and ever varying composition.

In spite of this, some progress is being made in water supply automation. Caution, lack of urgency, and inertia are its main obstacles; automatic measuring devices constitute its main problem.

Sheffield Plant

The Sheffield water plant is a conventional one; raw water is pumped from the river to the plant where chlorine is fed by an ordinary chlorine feeder and alum is added by a volumetric feeder. From the first mixer the water flows by gravity to the second mixer at the head of the settling basin—which has a 6-hr retaining period. From there it moves to three 667,000-gpd and 1-mgd rapid sand filters. Lime can be fed either ahead of the filters or into the clear well. Both chlorine and fluoride are fed into the clear well.

Obviously, in this arrangement, the control problem consisted in the starting and stopping—at the right times—of the raw-water pump, the chlorine feeders, the alum feeder, the filters,

lime feeders, fluoride feeder, and high-lift pumps.

Pump Control

Fortunately, the raw-water pump was controlled from the plant by a pushbutton and all that was necessary was insertion of a control in the pushbutton circuit. This was done simply by installing a level switch which was actuated by the level of the water in the settling basin. Perhaps the simplest device is a float switch but, because experience has shown that these are not entirely reliable, the electrode type of switch (Fig. 1) was selected. This employs two electrodes at the water surface that are connected to an isolating transformer which also acts as a magnet to open or close contacts in the pushbutton circuit. A 120-v power supply is connected to the transformer-magnet but the electrodes are provided with a much lower and safer voltage. Thus, the raw-water pump is started when the water level is low and stopped when it is high. There is no problem of priming.

Fig. 1. Electrodes for Control of Raw-Water Pump

Device is mounted on wall of settling basin. Water level has been reduced to expose rods.

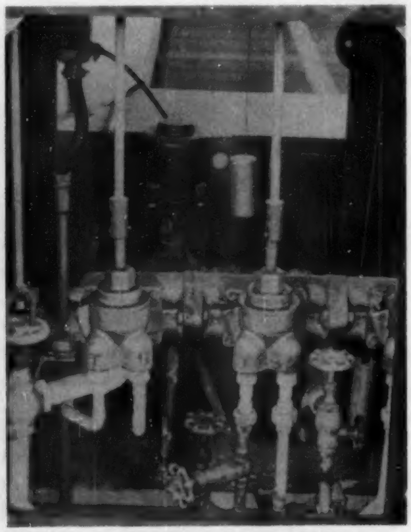

Fig. 2. Manifold Section of Filter Operating Table

Solenoid-operated four way valve is shown connected in parallel with manual four way valve.

Feeders

The prefiltration chlorine feeder operates when the raw-water pump is running and is controlled by the same circuit as this pump. A solenoid valve in the water supply and connected to the vacuum chamber of the chlorine feeder starts and stops the flow of chlorine. A valve in the chlorine supply could accomplish the same results but experience has shown that this is not as desirable as control through the water supply.

The alum feeder is also started and stopped in conjunction with the raw-

water pump. Its magnetic starter is controlled by the control circuit of this pump. Mixing water continues to flow while the feeder is stopped.

Filter Control

The level of the water in the clear well determines the operation of the filters. As with the settling basin and raw-water pump, the level in the clear well—acting through an electrode switch—starts and stops the filters. This is done by opening or closing each filter's hydraulic effluent valve which is controlled by a four-way solenoid valve connected in parallel with the standard, manual four-way valve (Fig. 2). These two valves are connected through four small gate valves in such a manner that either the solenoid valve or manual valve may be used without affecting the other. Manual switches in the solenoid circuits are used to isolate each filter from the control circuit when desired. Unless isolated in this manner, all filters are started or stopped simultaneously by the control circuit. Without a power supply the filter is stopped.

Other Feeders

The lime feeder, postfiltration chlorine feeder, and fluoride feeder—which operate at the same time as the filters—are controlled through relays by the clear-well electrode switch control circuit. This is done in the same way that the settling-basin circuit controls the prefiltration chlorine feeder and alum feeder.

Storage Tank Levels

With the treated water in the clear well, the two high-lift pumps of 1,400-gpm and 2,100-gpm capacity take over to supply water to the system which includes a 400,000-gal standpipe and a 500,000-gal elevated tank. Water level in the tank is indicated on the switchboard by a remote indicating device which uses a pair of conductors leased from the telephone company. The transmitter located on the tank riser translates varying pressure—as determined by water level—into electrical impulses of varying lengths. The receiver on the switchboard converts these impulses into water level indications which are recorded on a round chart. The receiver contains two mercury switches which are connected to the pushbutton circuit of the automatic compensating starters of the pump motors. This control circuit of the receiver is divided by a double-throw switch so that the level indicator can control either pump as selected by the operator. Each control circuit has a switch for automatic or manual control.

Priming System

Because the pumps are located over the clear well, it is necessary that a priming system be used. Jets are used to provide a vacuum for removing air from and supplying priming water to the pumps and suction pipes. The jets are controlled by a float in an enclosed chamber attached to the suction pipe and slightly higher than the pump. Until the level in the chamber is at the correct height, the pump is not primed and the float connected to an electric control switch keeps the jet operating. This switch has two sets of contacts, one of which is connected in series with the pushbutton circuit of the pump starter. Unless the contacts are closed, the starter will not operate—regardless of the level control. If the pump were to lose its suction, the float would fall, the contacts would open, and the pump stop.

Although two jets are installed, only one is necessary. Of the two, one is

supplied with water by a pump in a closed circuit and is started or stopped by control of the pump motor; the other is supplied from the plant high-pressure system to which it is connected by a 1¼-in. solenoid valve.

Altitude Valve

The elevated tank and the standpipe are located on the system at different hydraulic-gradient levels, making an altitude valve necessary at the standpipe. Originally installed was a pressure-controlled valve which was found completely unsatisfactory. The standpipe was usually either overflowing or nearly empty. As a corrective measure, a check valve was installed parallel to the altitude valve and positioned so that water can always run from the standpipe through the check valve. An electrode switch similar to those used in the settling basin and clear well was installed to control the hydraulic cylinder of the altitude valve through a four-way solenoid valve such as those used for the filters. This keeps the standpipe full except at the occasional times when water is required from it. Except for the unlikely possibility of sticking of the gate, water is assured for emergencies without possibility of malfunction of pressure control devices.

A minor part of the distribution system is at a higher elevation than the rest, making necessary higher tanks and a booster pump. This pump is controlled by an electrode switch similar to those described. It has worked for years without trouble and with virtually no attention. With use of a ground return, only one wire is necessary between the tank and the pump.

Alarm Devices

In addition to the strictly control devices, there are several others used for alarm in case of malfunction of the controls or other trouble. Electrode switches are used for indicating excessively high or low water in the settling basin and in the clear well. Additional mercury switches in the tank-level indicator are connected to indicate excessively high or low tank levels. All alarm circuits are connected to a common point from which an inside bell and an outside horn are sounded. An alarm-off switch is connected so that when in the off position a red light cautions the operators against leaving it so by oversight.

All wiring is in metal conduit. Cost of the entire installation was $3,380. All solenoid valves were provided with strainers and pressure regulators adjusted to 50 psi.

Availability

The devices and their functions have been outlined for general understanding of the system which, by a broad use of the term, may be characterized as automatic. Actually, the system described simply employs, in one plant, a number of devices which have been in common use for a number of years. Nothing was invented and everything was ordered from catalogs. There is certainly nothing new in automatic control of pumps or in starting and stopping a chlorine feeder in conjunction with the starting and stopping of a pump. The use of solenoid four-way valves for controlling the flow through the filters may be unusual, but it amounts to little more than shifting control levers on operating tables.

Dependence on Storage

Automatic equipment does add in some measure to the reliance which must be placed on storage capacity but, with ample storage capacity, reliable basic machines and equipment, and

reliable and tested automatic controls, the additional reliance is small.

Dependability

Failure to deliver water, properly treated, is of first importance in case of malfunction of automatic equipment; the possibility of plant damage, however, is also worth considering. Considering this and beginning with the raw water again, lack of water would cause no damage and excess water would simply go down the drain. The filters, being on the same level with the settling basin overflow, cannot themselves overflow. Failure of a supply to the filters would result in drained filters but no damage. Excessive water to the clear well would merely overflow to the drain. Lack of water in the clear well would result in loss of suction for the high-lift pumps and their immediate shutdown—with no damage incurred.

Power failure to any control would result in stopping of the component controlled. Restoration of power supply would result in resumption of operation if the control called for operation. Complete power failure would have no effect—except that the plant would be idle during the failure.

Conclusion

The benefits of automation are twofold. First, one shift of 8 hr during the night, is controlled automatically. This amounts to a third of the total operating time—with a corresponding saving in labor cost. Second, the automatic equipment remains in operation continuously, allowing the operator when on duty to carry on testing, bin filling, maintenance, and housekeeping without the necessity of constant gage reading.

Many references to automation in water plants suggest that there is little to be gained in the way of labor saving. This attitude is subject to question. With labor saving the order of the day in almost every commercial, industrial, and even home operation, why should water plants be excluded? In the Sheffield plant, one shift was selected for automatic operation, principally because of ease of scheduling. There is no basic reason why greater use cannot be made of it. Naturally, there is a limit—because of the necessity of changing chemical dosages from time to time and the need for inspections and tests. Raw-water conditions vary and the chief operator has to be mindful of changes in the river condition, rainfall, and special conditions which may develop. These things, however, do not come about without advance indication and the chief operator is free to change schedules according to them.

Although the author is not qualified to act as a prophet in such matters, it is felt that water treatment will be increasingly subject to procedures similar to those used in other chemical processing plants. The complexity of water at any one plant is not so great that measuring and testing devices and processing methods and machines cannot be developed to treat water completely automatically through the full range of its changing conditions. It appears that the principal need is for accurate and reliable recording, testing, and measuring devices. When industry pressure for these devices becomes great enough, they will be developed. The pressure will mount as more engineers and operators realize that water treatment can be and should be as modern as other industrial processes.

Water Quality From the Standpoint of Irrigation

Lloyd V. Wilcox

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Lloyd V. Wilcox, Asst. Director, US Salinity Lab., US Dept. of Agriculture, Riverside, Calif.

IN most localities in the West, the city water supply serves the homeowner not only with household water but also with water for the irrigation of his lawns and plantings. An excellent water may be of inferior quality for irrigation use; in fact, water quality criteria, from the viewpoint of soil and plant relationships, differ in most respects from the criteria for domestic or industrial water. For example, irrigation water should contain a relatively high proportion of calcium plus magnesium, whereas soft water is preferred for domestic use. The concentration of boron in irrigation water should not exceed 1–2 ppm, although these concentrations are not important in domestic waters. Silica and fluoride are undesirable constituents in household water but present no particular hazard in irrigation water. One quality preferred in all waters is a low total salt content. These characteristics and the soil-plant relationships are to be discussed here and also to be considered are problems commonly encountered in the use of domestic supplies for irrigation.

Salt Content

Total salt content, most important consideration of irrigation water quality, is usually expressed in terms of electrical conductivity—micromhos per centimeter—although dissolved solids expressed in parts per million can be used. The range of conductivity of most irrigation waters is approximately 0–5,000 micromhos/cm, with waters of somewhat higher salt content being used during water shortages. These values correspond to 0–3,500 ppm dissolved solids. About half the irrigation waters now in use in the West fall within the conductivity range 250–750 micromhos/cm or 175–500 ppm dissolved solids. For purposes of classification, irrigation waters are divided into four salinity groups: low salinity, less than 250 micromhos/cm; medium salinity, 250–750; high salinity, 750–2,250; and very high salinity, greater than 2,250 micromhos/cm.

Soils are seldom adversely affected by saline irrigation waters provided the sodium concentration is low in relation to the concentration of calcium plus magnesium. Plants, on the other hand, find it more difficult to obtain water from saline soil solutions. The osmotic pressure of such solutions interferes with the movement of water from the solution into the plant root and, under these conditions, the plants may suffer from incipient drought (Fig. 1). Often the plants show no visible symptoms of injury other than being stunted and dark blue-green in color. There are exceptions, however,

especially among the stone fruits which are sensitive to high concentrations of sodium or chloride and show characteristic leaf burning.

Sodium

The relationship of sodium to the dibasic cations calcium and magnesium is the second most important factor in determining irrigation water quality. Sodium can be expressed in parts per million, milliequivalents per liter, or as a percentage, but none of these methods of expression is satisfactory—particularly in dealing with soil relationships. Comparatively recently, a term was proposed (*1*) called the sodium adsorption ratio (SAR) which is defined:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}.$$

There is a highly significant relationship between the SAR of an irrigation water and the exchangeable-sodium percentage of the soil irrigated with that water. It is possible, therefore, knowing the SAR, to anticipate with a good deal of confidence the effect of a water on the soil. Irrigation waters with SAR values of 8 or less are probably safe. Values of 12 or 15 are marginal and continued use of waters with values much greater than 20 would undoubtedly lead to serious sodium problems.

Surface waters, in general, have low SAR values and are safe for irrigation as far as sodium is concerned. Many ground waters are high in sodium with correspondingly high SAR values. Such waters present definite sodium hazards and, if used, must be managed properly.

Both soils and plants are adversely affected by high-sodium irrigation waters. Sodium soils are relatively impermeable to air and water. They are hard when dry, difficult to till, and plastic and sticky when wet. These adverse physical conditions retard or prevent germination and are generally unfavorable for plant growth (Fig. 2). In addition, the sodium ion is toxic to many plants.

Boron

Boron is the characteristic element of such well known compounds as boric acid and borax. It is essential to normal plant growth but concentrations only slightly above optimum are toxic to many plants. It is present in all natural waters probably in the form of non-ionized boric acid (H_3BO_3) and is reported in water analyses in parts per million. Only a few surface waters contain toxic concentrations of boron but many ground waters and many saline soils are contaminated. Permissible limits of boron in irrigation water are 0.3–1.0 ppm for sensitive crops, 1.0–2.0 ppm for semitolerant crops, and 2.0–4.0 ppm for tolerant crops. The sensitive group includes such crops as citrus, other fruits, nuts, and beans; the semitolerant, cereals, some vegetables, and cotton; and the tolerant group, alfalfa, sugar beet, asparagus and others. A complete list is available from the US Department of Agriculture.

Boron, in the concentrations found in irrigation waters, has little or no effect on soils but produces characteristic injury symptoms which appear on the leaves of most plants. The injury appears as a burning and browning of the leaf tip followed by yellowing of the margins. Retarded growth and premature shedding of leaves are other symptoms. Apples, pears, and the stone fruits are sensitive to boron in-

Fig. 1. Very Saline Area in Barley Field

Effect of salinity is shown by extreme retardation of growth.

Fig. 2. Effect on Bean Plant of Different Levels of Salinity and Sodium

Plants at top are growing in saline soil, those at bottom in soil containing exchangeable sodium. Salinity and sodium levels increase from left to right.

jury but do not show typical leaf burning.

Bicarbonate

The precipitation of calcium carbonate as a scale in distribution lines, boilers, water heaters, and other equipment is familiar to all. The same reaction can take place when irrigation water is applied to a soil. As calcium precipitates, the ratio of sodium to calcium increases, with a corresponding increase in the SAR value. Bicarbonate waters, therefore, represent a special type of sodium problem and can be troublesome.

Control

A water can be classified as to its suitability for irrigation on the basis of a chemical analysis and certain assumptions regarding the conditions under which the water is to be used. It is usually assumed that normal conditions will prevail but this is often not the circumstance. The more important factors that determine the success or failure of an irrigation venture are drainage, leaching, choice of crops, and control practices.

Drainage

Salt is added to the soil with each irrigation. If drainage is impaired, a water table may develop and salt will accumulate in the root zone of the soil. It is usually necessary to install a drainage system to prevent the rise of ground water. Adequate drainage is the most important factor; without it, failure is inevitable, and with it, some success can be achieved even with saline irrigation water.

Leaching

Adequate drainage is essential, not only to control the water table but also to permit leaching of the soil. Plants take water but very little salt from the soil solution. The salt that is left in the root zone with each irrigation must be leached below that zone and carried away in the drainage to prevent salinization of the soil. Usually sufficient leaching takes place under flood- or basin-irrigated fields. Furrow or sprinkler irrigation systems, however, may not provide sufficient water for leaching. In the humid area where supplemental irrigation is used, little attention has been given to leaching, it being assumed that the rain would leach out the salts. Occasionally, however, during prolonged droughts, saline conditions have developed which resulted in severe crop damage.

Choice of Crops

Crops should be selected on the basis of their salt tolerance and the salt content of the irrigation water and the soil. The relative salt tolerance of the more important crops follows:

Salt-Sensitive

Avocado	Prune
Citrus	Apple
Strawberry	Pear
Peach	Beans
Apricot	Celery
Almond	Radish
Plum	Clover *

* Most species.

Medium Tolerance

Grape	Olive
Cantaloupe	Fig
Cucumber	Pomegranate
Squash	Cauliflower
Peas	Cabbage
Onion	Broccoli
Carrot	Tomato
Bell pepper	Oats
Potato	Wheat
Sweet corn	Rye
Lettuce	Alfalfa

High Tolerance

Asparagus	Barley
Garden Beets	Cotton
Sugar Beets	

A list of the salt tolerances of most crops is also available from the US Department of Agriculture.

Special Practices

There are certain practices that are useful where it is necessary to use saline irrigation waters. Fine textured soils, especially if they contain sodium, should be worked or cultivated as little as possible when moist. An occasional application of gypsum may be desirable.

Plants are most sensitive to salt injury during the germination stage. The high crowned, single-row, planting bed is particularly bad under saline conditions. The salt tends to accumulate at the top of the bed where the concentration may be as much as 50 times as high as that at the bottom of the irrigation furrow. Double-row or sloping beds are better for salty soils.

Other Aspects

Salinity is the problem most frequently encountered in the use of city water for the irrigation of lawns, ornamentals, gardens, and other plantings. Usually, difficulty arises from a lack of leaching. It is a common practice to water lawns with frequent light applications. There is essentially no leaching under such conditions and, as a result, the salt concentrates in the top few inches of soil. The same difficulty may develop where shrubs or ornamentals are irrigated by sprinkler. Potted plants and greenhouse plantings are seldom leached thoroughly and heavy applications of mineral fertilizer and salt accumulation from the irrigation water often lead to salinity problems. The proper procedure, in all these situations, is to apply a heavy, leaching irrigation several times a season. This should control the salinity and permit the growth of the plants that are in the proper range of salt tolerance for the irrigation water used.

Softened water is a source of other problems. Completely softened water —that is, water containing relatively high concentrations of sodium and little or no calcium or magnesium—is wholly unsuitable for irrigation use. Soils irrigated with such waters would be converted to sodium soils with all of the attendant adverse physical and chemical characteristics. In addition, the high sodium content would be toxic to many plants. Partially softened waters would be less harmful but would probably require occasional applications of gypsum.

The salt tolerance of plants is another factor that should be considered. Many municipal systems furnish waters of relatively high salt content. Under these conditions, it would be futile to irrigate salt-sensitive plants. Similarly, boron-sensitive plants should be avoided if the water supply is high in boron. As mentioned above, both salt and boron tolerance lists are available and should be useful in the situations just described.

Reference

1. *Diagnosis and Improvement of Saline and Alkali Soils.* US Dept. of Agriculture, Handbook 60 (1954).

Problems and Techniques in Population Forecasting

Paul M. Reid

A paper presented on Sep. 27, 1957, at the Michigan Section Meeting, Detroit, Mich., by Paul M. Reid, Exec. Director, Detroit Metropolitan Area Regional Planning Com., Detroit, Mich.

FORECASTING population growth of local, county, metropolitan, and state areas has become a practical process. Agencies—both governmental and private—that utilize population forecasts have come to look upon such material as a necessary tool for sound planning of future facilities and developments. The making of population forecasts has developed into something more than an intellectual exercise or a matter of mathematical mechanics. The technical and scientific aspects of population projections have been refined greatly over the past 10–15 years. Population specialists have not been content to formulate a forecast and then sit back with an air of cosmic complacency. They have sought to refine their methods, assess the variables, and narrow the possibilities of errors.

Modesty and humility continue to be valuable attitudes in the forecaster. He knows that he can neither predict the acts of God and nature nor anticipate the follies of man; moreover, he has come to realize that neither governmental nor private interests can be expected invariably to follow either the logic or the economics of sound urban development. Special-interest group pressures, political expediency, and satisfaction with any growth—whatever its form or quality—too often determine both short-time and long-range population developments of an area.

Importance

Population forecasting is now a basic factor in calculating market demand, both for public and private agencies. In the Detroit area, the "big three" of the auto industry maintain competent and large staffs for this purpose. These market analysis experts are concerned not only with total national demand for cars and trucks, but also with a breakdown of this demand according to state, metropolitan area, and dealers' territories. Department stores, food-retailing chains, variety stores, and a host of other retail enterprises try to do the same for their economic fields. In the social-agency and church field, there is an increasing tendency to estimate market demands for welfare and religious services. Almost every agency of government—from the townships and villages to the state—feels the need for reliable data on which to base the continuation, expansion, or curtailment of its activities and services. From the case load of public welfare agencies to the extension of water and sewer services, police and fire protection, and school facilities, the desire for reasonable data

on which to base next year's operations and plan the scope of services 5, 10, and 15 years ahead has become more and more insistent.

Applicability

In forecasting, the larger the universe—the area for which the forecast is attempted—the smaller the error. Forecasting the population of the United States entails fewer hazards than projecting the populations of Michigan or the city of Port Huron. On the whole, birth and death rates, net in-migration, natural disasters, and economic fluctuations are apt to level out for a large area. Within a state, a metropolitan area, or a city, however, such factors as tax laws, floods, epidemics of disease, and the awarding of government contracts can have a very upsetting effect on trends and even potentials.

Dependence on one variety of expert or one set of factors in making population forecasts can be very dangerous. Those who seemed to know the most about birth and death rates nationally have made some glaring misjudgments. In the early 1940's, it was calculated that the national population would level off before 1975. It was found by 1950 that the number of children per family was more than a mere matter of economics and security; that family fulfillment, group standards, and social ideals had a very pronounced effect together with the changing economic situation. Thirty years ago none would have dreamed that population mobility would have such a sharp influence on the growth and decline of the various areas of the nation.

From a practical, end result standpoint, the best population forecasts have been the products of the efforts of groups of various experts. The combined product of economic experts, vital-statistics savants, and students of population movement tends to be more reliable than the output of any one type of specialist. One expert defending a fixed forecast has little chance against a group product of this character. In the Detroit area such a combined approach has been in operation for over a decade. In 1953, the regional planning commission formalized these efforts in a population and housing committee. This committee has made yearly estimates and also population forecasts to 1970 and 1980. It is composed of economists, vital-statistics specialists, housing and retail-market analysts, public utilities men, planners, and statisticians. Its yearly work is recognized and used throughout the region by governmental units, business interests, and social agencies.

Bases of Population Change

Population growth or decline is based on two major factors: natural increase—that is, the excess of births over deaths—and net migration—the surplus (or loss) which derives from the movement of families into and out of an area. Unfortunately, birth and death rates do not remain constant nor does net migration stay at the same level, year after year. Thus, even the making of annual population estimates contains its hazards and uncertainties. As a guide, it must be recognized that, usually, the larger the population base the more significant is natural increase as against net migration.

Economic conditions—the tempo of industrial, commercial, and service activities, with the resulting employment and wage rate levels—have a decided impact on the population growth fac-

tors of natural increase and net in-migration. Hence, analyzing economic trends and assessing economic potentials are important steps in developing population forecasts. Whatever the area for which the forecast is being made, consideration must be given to external as well as internal economic forces. World trade conditions have an effect on the economy of the nation just as metropolitan business conditions have an effect on the economic health of a suburban community.

Urban-Fringe Forecasting

Forecasting the population of cities, villages, and townships in a metropolitan area presents special problems. As population growth has spread from the central city to the fringe areas and to suburban or detached subcenters, the old guide lines for forecasting growth have become inadequate. Waves of in-migration have become the controlling factor. Location of a manufacturing plant—whether it employs 500 or 5,000 people—in a township usually has a pronounced effect, after a time, on population growth in places 5–20 mi away. The magnet of a new suburban shopping center is apt to spur new residential developments within a range of 5–10 mi to a degree that is perplexing to local governmental units and confounding to school authorities. The vaulting of subdivisions into rural areas confuses even the short-range forecaster even more.

The growth potentials of too many Michigan communities are handicapped at present by inadequate water services and sewer facilities. Ample supplies of water are near at hand in the Great Lakes that practically surround the state. The speed and extent to which these resources are developed with treatment plants and transmission lines will be a major factor in enhancing Michigan's population growth through both industrial and community development. The attractiveness of a community—as a living and working area—is a big factor in population growth. By attractiveness is meant something more than sufficient water and sewer services and an abundance of jobs. It means in addition, good homes, paved streets, adequate and modern schools, and convenient shopping facilities, churches and recreational facilities.

Procedures

A backward look is imperative in preparing to make population forecasts. For, whatever the area concerned, it is important to know what the past population growth has been. Depending on the character and age of the community or area, examination of such growth should reach backward 20–50 years. Of course, the decennial United States Census provides the best data for this purpose.

It is not enough to limit this backward look to just the unit of government with which the forecast is concerned. The growth of this unit must be compared with a larger territory—the county, the metropolitan area, the state, a group of states, or the nation. For example, in 1930, Michigan's population comprised 3.944 per cent of the nation's population. By 1950, the ratio had risen to 4.228 per cent. This meant that Michigan was growing at a faster rate than the nation as a whole. In 1930, the population of Detroit was 72.04 per cent of that of the metropolitan area of three counties. By 1950, Detroit's population was down to 61.32 per cent of the area. In the 20-year period, the city grew at

a slower rate than did the metropolitan area.

Between the federal decennial censuses, it is helpful—and often necessary—to make some estimates of current population. The population committee of the Detroit Metropolitan Area Regional Planning Commission has utilized these kinds of materials in making yearly estimates:

1. Birth and death data from health departments
2. Residential building-permit data from building inspectors
3. Home electric meter data from a Detroit electric utility
4. Annual school census data from school districts
5. Labor force data from the Michigan Employment Security Commission.

Thus, when the 1970 and 1980 projections were made, the commission had past data for the years 1930, 1940, 1950, and 1955 as a series upon which to establish relationships and ratios.

The procedure that was used in making population projections or forecasts for the Detroit Region is as follows: First, a series of past growth relationships or ratios is established for the Great Lakes states and the United States, for Michigan and the Great Lakes states, and for the Detroit region and Michigan. The ratios are then projected to 1970 or 1980. As is well known, in the past several years the US Bureau of the Census has produced several series of estimates for 1970. Each series is based on certain assumptions in regard to migration into the United States, fertility rates of females approximately 14–45 years old, and mortality rates. The effect of such a series is to provide a low, a high, one or more intermediate estimates, and, thus, a range. For example, on August 9, 1957, the census bureau released the 1970 population estimates for the United States. They compare with the Aug. 21, 1953 estimates as follows:

Aug. 9, 1957	Aug. 21, 1953
208,346,000	204,222,000
203,688,000	202,359,000
203,688,000	196,269,000
195,438,000	189,110,000

The 1957 series figures vary from those of 1953 by 1,300,000 to 7,400,000. Detroit has been somewhat conservative in its use of the ratios, taking a lower rather than a higher estimate. It has also been found more effective to have one figure instead of a low and a high estimate.

The series for 1970 for the state of Michigan runs from 9,392,000 to 10,483,000. Michigan, as a key part of the Great Lakes industrial area, is expected to continue to show population gains at more than average rates for the next 20 years. The extent of these gains, however, is not only subject to national economic conditions but also to state and local efforts to maximize both the economic attractiveness of the area and its attractiveness as a place to live.

Whether Michigan attains a 1970 population of 9,392,000 or 10,483,000 —the latest low and high estimates of the census bureau—depends in no small measure on rapid steps both by the state and by local communities. Governmental agencies must accept the challenge and the responsibility for providing the magnitude and attractiveness of public facilities required to retain existing population and to stimulate the in-migration of hundreds of thousands of new families.

On the basis of the estimated 1970 ratios of the relationship of the De-

troit region to United States and Michigan estimates—made on the 1953 series—the commission arrived at a population forecast of 4,620,000 in 1970 for the Detroit region.

Other Methods

In the past, two other methods of making population projections have been used. The relationship of past growth in population to past growth in employment, has been studied and the ratio established. After extending this ratio into the future—perhaps to 1970—employment for that year was estimated on the basis of past trends and the supporting population was developed from the extended ratio.

The third method involved the use of estimated (crude) birth rates and death rates plus anticipated net in-migration on an average yearly basis. The results of these three steps were averaged in the original population forecasts. In more recent projections, calculations have simply utilized the census bureau national and state estimates for 1970 and employed the ratio method for the Detroit region.

County and Local Units

Since most interest is probably centered on either county or local governmental-unit forecasts, the following suggested procedure should prove helpful: If the problem is to make a forecast for a city, village, or township, first relate the past growth of the unit of government to the county by ratio, then do the same for the county growth in relation to that of the state. The census bureau provides estimates for 1960, 1965, and 1970. The ratios established from past growth should then be extended to the year desired and the percentage taken for the unit of government in question—on any one or all of the series of census bureau estimates. If the problem is a population forecast for a county, the procedure is shortened by one step.

For local units of government a procedure which is felt to be better has been used. After establishing the forecast for the county, there is then determined the percentage of the county population gain that the particular unit of government accounted for in a specific past period of significant duration. It is then assumed that the local unit would show the same percentage gain of the projected total county gain. For example, Royal Oak City in the period 1940–55 showed a population gain of 40,413 people. This was 14.03 per cent of Oakland county's 1940–55 gain of 287,932. From 1955 to 1970, it was estimated, the county would gain 336,000 people. Thus, Royal Oak's share—14.03 per cent—of the gain would be 51,408 for the 1955–70 period. Some adjustments are needed at times in these percentage-of-gain figures, but they do provide what is felt to be a better method for small units than the straight ratio process.

Limiting Factors

Several limiting factors and precautions should be noted. Some estimate of the holding capacity of the land is needed in order to know whether a population forecast is reasonable. For example, places in Michigan like Detroit, Ferndale, and Ecorse City are built up and have little room for more people. Regardless of past growth trends, people cannot be put where there is no room for them. To be realistic, it is best not to calculate that an area will ever have 100 per cent of

all of its residential lots and areas occupied. Computations should be conservative and limit the holding capacity to 95 per cent of the residential land available. Further, the speed of population growth (in spite of past trends) is likely to be reduced if such public facilities as water mains and sewer lines are not built in time. Finally, if population forecasts are being made to determine water or sewer extensions and installations, the forecast should be for a period sufficient to include time for financing and bonding. This is usually in the vicinity of 30 years, rather than 10 or 20.

Revised Concrete Pipe Standards Available

In July 1957 the AWWA Board of Directors approved revisions of the AWWA standards for reinforced concrete pipe of steel cylinder type, *not* prestressed (AWWA C300), and noncylinder type, *not* prestressed (AWWA C302). The revisions were extensive, affecting most of the sections in each standard. Revised printings bearing the designations C300–57 and C302–57, respectively, are available. (Note: All copies designated C300–57 and C302–57 contain the latest revisions.)

The standard for concrete pipe of steel cylinder type, prestressed (AWWA C301), had previously (1955) been revised. This document was made Standard by the Board of Directors in January 1958, without further revision. Accordingly, the next printing (to be made when current stocks are exhausted) will be redesignated AWWA C301–58, but all copies bearing the designation C301–55T contain the latest revisions.

Advantages of Additional Storage Facilities for Improving Distribution Systems

Donald E. Stearns

A paper presented on Apr. 11, 1957, at the New York Section Meeting, Elmira, N.Y., by Donald E. Stearns, Civ. & San. Engr., Cazenovia, N.Y.

THE problem of improving a distribution system in order to improve water service becomes largely a matter of economics. New main constructions may take the form of a feeder loop in the system, individual mains to provide stronger cross feeders, or new mains to tie in dead ends and thus provide a broader pattern of flow.

The place of water storage in the program of improvement is often not well understood. It is usually difficult for the engineer to convince those charged with the operation of the water system of the wisdom of additional water storage as a part of the strengthening program. Somehow, the main laid in the ground, and thus out of sight, seems to gain public favor more than a storage facility with its maintenance requirements, despite the fact that a combination of the two may be the economical way to solve the problem.

In order to demonstrate the relationship between cost of mains, cost of storage, or a combination of mains and storage, a number of water systems have been chosen that have been hydraulically analyzed and for which actual improvements have been recommended within the past few years. Some small and relatively simple systems have been selected, as well as more involved systems. For the most part, costs have been determined for strengthening by mains alone and then by gaining the desired improvement through storage properly tied into the system.

Purpose of Improvements

Sustaining water pressures in a distribution system during periods of fire draft is generally the objective to be sought in a water utility improvement. The lower the static head in the distribution system, the more important it becomes to sustain pressures during high drafts. This can usually be accomplished either through adequate main sizes, storage within a reasonable distance of the demand, or a combination of mains and storage.

The idea seems to prevail that high static pressure automatically means an adequate water supply to meet demands. Recent tests by the author's office on two different water systems showed a pressure drop from 104 psi to 75 psi in one system with an adequate fire flow. This indicated a highly satisfactory residual pressure and excellent main support. In a second test, a static of 90 psi dropped to a residual of 6 psi with a less than standard fire flow. Certainly this latter system is a good example of inadequate main, and possibly tank storage, support.

Examples

Earlville, N.Y., has a small water system with gravity flow from an earth embankment storage reservoir located about 2½ mi from the center of the village. Fire flow at the center of the village mercantile area was measured at 295 gpm maximum at a 20-psi residual pressure. Studies and cost estimates showed the best solution to be that of floating a steel reservoir or standpipe of 200,000-gal capacity on the system, the reservoir to be located on high ground within ½ mi of the center of the village. The cost of the storage reservoir, together with connecting main and appurtenances, was estimated to be $48,000. A new supply main, running parallel with the existing main and sized to provide the desired improvement, cost $132,000. This would indicate that storage with proper main tie-in to the system would cost about 36 per cent of the amount of expenditure required for the improvement with pipe mains alone and would accomplish the same purpose.

In Oxford, N.Y., the distribution system is made up of two areas separated by a river. A ground storage reservoir of 220,000-gal capacity was built with the initial system and located on the west side. Despite the fact that a suitable high point within the corporate limits of the village on the east side of the system was available for new storage facilities, two additional reservoirs of 450,000-gal total capacity were constructed adjacent to the original reservoir.

It has now become necessary to provide new storage facilities on the easterly side of the village opposite the present three reservoirs. The cost of building the new reservoir, together with connecting pipe, has been estimated at $58,000. There will be no increase in pumping costs, as the new facility will float on the system at an elevation consistent with the water level in the present reservoirs. The cost of building a new supply main of sufficient size to accomplish the same result is estimated at $80,000. The tank facility offers a more secure solution than the new main as well as being less costly.

The village of Cazenovia, N.Y., has 7 mil gal of storage in the form of an impounding reservoir, which serves the village by gravity. About 10 years ago, two deep wells were put down within the village limits. Pumps were installed, and the needs of the community are currently met through this well supply. Surplus pumpage now flows into the storage reservoir and wastes over the spillway, since one pump is run continuously. Present storage facilities provide standby water for emergency use. The general condition of the storage reservoir is very poor.

A new 300,000-gal steel reservoir is proposed on high ground within the village limits, to be located on the opposite side of the village from the pumping station and the present storage. The new tank will have a high-water level 25 ft higher than the present reservoir, which will bring the present static level of 59 psi up to 70 psi. The present fire flow at the center of the village is 690 gpm. The new tank with supporting mains will bring this flow up to 1,620 gpm at a 20-psi residual pressure. A flow of 1,500 gpm is required to meet fire underwriter standards.

The total cost of the proposed new facilities is $120,000. It is difficult to determine the cost of main strengthening alone to accomplish the same result, as the need for storage at a higher

level than the present storage facilities is essential in maintaining a higher static pressure. To utilize the present reservoir would require a new supply main to the village at an estimated cost, along with system strengthening, of $150,000, but the raising of the static level would not be accomplished. A raising of pressures is essential in improving service and maintaining a better residual during periods of high draft. The building of mains alone does not solve the problem, and would cost about 25 per cent more in actual capital outlay.

In Skaneateles, N.Y., pressures were raised through storage at a higher static level. This is another example of system improvement that could not be accomplished with mains alone. In this village a new main was constructed near the tank, to provide a strong loop for feeding the tank and for taking drafts from the tank into the distribution system. Another main construction near the pumping station provided a dual feed from the pumping station into the system. These two improvements, coupled with a third main construction within the distribution system, provided sufficient reduction in the total friction loss across the distribution system when pumping, so that the static water level in storage was raised 75 ft without replacing or supplementing the pumping equipment.

At Norwich, N.Y., strengthening was accomplished by storage and adequate feeder mains to the storage facilities. In this community, the need for improvement was great. During periods of heavy draft, there was a drop in pressure of 10 psi or more at the center of the city. The available fire flow amounted to 900 gpm in a high-risk area, where 3,000 gpm was required as a minimum for adequate fire flow. The floating of a 1.5-mil gal reservoir on the distribution system at proper elevation brought fire flows up to 3,100 gpm in the area. The system has a gravity supply and a treatment plant. The new storage has taken away the peak demands on the treatment facilities, and it assures, not only adequate fire flows, but also sustained flows and pressures for a major fire demand.

The cost of the new tank facility, with supporting mains, was estimated to be $165,000. The cost of providing sufficient main strengthening without a tank to provide the same improvement in the center of the city was estimated to be $201,000. Even with the greater expenditure, there would have resulted a much narrower area of improvement than that now available with the tank facility.

The Geneva, N.Y., distribution system has, at present, storage and pumping facilities on one side of the system and most of the fire risks on the opposite side. An increase in fire flows to the extent of 300 per cent of present flows is required to meet acceptable standards.

Hydraulic studies showed that elevated tank storage of 1-mil gal capacity at a location on the north side of the city, with adequate main support to the tank, would cost $330,000. The studies showed that a supply main of adequate size to bring the required amount of fire flow into the area with adequate pressures would cost $620,000, or nearly 88 per cent more.

In this situation, there was strong public opinion in favor of main constructions rather than new storage facilities, but the matter of economy was not considered in its true light. Somehow, the idea prevailed that additional pumping would be required to take

care of the new proposed storage facilities. Aside from the water required to fill the tank when first put in service, there would be absolutely no change in pumping required, and this additional storage would also be available to meet peak demands in the city.

Canastota, N.Y., has a distribution system with a 2-mil gal steel reservoir floating on the system to the south and a water source from wells on the north. Storage is quite adequate for the size of the system, but adequate fire flows are not available in the high-risk area of the village. Storage without adequate main ties to the system is not effective.

In this community it was felt that the supply main from the pumping station could be extended to the high-risk area. The amount of fire flow, however, would be dependent on the capacity of the pumps and water treatment facilities at the pumping station.

It is far more economical to provide proper main support for the high-risk area in this situation than to extend the large main from the pumping station and to augment the pumping and water treatment facilities to meet peak fire demands.

Conclusions

The examples shown seem quite conclusively to favor, as the most economical answer, the use of storage within the distribution system, with proper main construction, rather than an attempt at improvement through main construction alone. It should be noted that many water distribution systems already have some storage but may not have this storage in a location that will properly support all parts of the community. In that event, either new mains must be constructed or additional storage facilities provided in the critical areas, unless there are other basic requirements, such as a general raising of static pressures or higher pumping capacity.

In these days of high costs, it is important that a careful and thorough study of hydraulic conditions be made on a water system, together with costs, in order to arrive at the most economical plan of improvement. The theory that replacing existing mains with larger mains is bound to improve conditions may have merit, but usually results in a costly construction that cannot be justified if the matter of economy is properly recognized. Certainly, the part that new storage facilities can play in the improvement program should be carefully weighed. Storage, properly integrated in the distribution system, may prove to be the sound answer to system strengthening.

Better Water Supply for Wayne County

Joint Discussion

A joint discussion presented on Sep. 26, 1957, at the Michigan Section Meeting, Detroit, Mich.

Development of the Metropolitan System—*George R. Bingham*

A paper presented by George R. Bingham, Asst. Engr., Water Supply, Board of Wayne County Road Comrs., Detroit, Mich.

IN order to discuss the development of the Wayne County Metropolitan Water Supply System, it is necessary to explain, briefly, the earlier development of Wayne County's Metropolitan Sewerage and Sewage Disposal System.

Prior to the late 1930's, water supply and sewage disposal for the communities on the fringe of the Detroit metropolitan area were almost exclusively on a local community basis. During the late 1930's, Wayne County sponsored a number of sanitary sewerage and sewage treatment installations, the construction of which was partially financed by WPA and PWA grants—the county's share coming in part from welfare funds.

By October 1938, the construction of this system was well under way, and at that time the county board of supervisors provided for the establishment and construction of a county-wide sewage and water supply project. In 1939 the legislature of the state of Michigan enacted Act 342 of PA 1939, providing authority under which counties having a population of 500,000 and more could establish and construct sewage and water supply works. The board of supervisors of Wayne County resolved to confirm their previous action, and established in the county the authority to obtain the benefits of Act 342.

It is under the provisions of Act 342 as amended that the Wayne County Metropolitan Water Supply System operates. The board of supervisors designated the Wayne County Road Commission as its agent in operating the water supply system. This should answer a question which may have arisen: "How did the road commission get into the water supply field in the first place?"

Actually, the first county efforts in the direction of water supply were for county institutions. The general hospital and infirmary at Eloise required the construction of a 12-in. main in Michigan Avenue and the New York Central right-of-way from Telegraph Road to Eloise. Another 12-in. main was built to serve the training school and later extended to serve the Detroit House of Correction.

Expanding Facilities

It was not until a few years later, however, during the early years of the war, that transmission mains of significant capacity were built. At that time the war effort required greatly increased water supply for industry and for the temporary housing. The Down River Transmission Main serving the Naval Air Station on Grosse Ile, as well as the Michigan Avenue Main extending to Wayne Village, were built by the road commission, acting as agent for the federal government. These mains were later sold to the Wayne County Metropolitan Water Supply System.

It subsequently became necessary to add booster stations and then reservoirs on these mains to keep up with the growing demand. In 1947 the city of Detroit and the Wayne County Metropolitan Water Supply System entered into an area water supply agreement, and the city of Detroit gave notices of cancellation of contract to its suburban customers who were not buying water directly from city mains. This area water supply agreement specified an area to be served, rather than any specific number of people or installations, and soon it became necessary to extend transmission mains and to build additional storage and pumping capacity. In August 1954, the Detroit water board advised the Detroit common council that it could not continue to supply the out-county area. As a result of the common council's action in requesting Wayne County to develop its own source of water supply, the intake, tunnels, filtration and pumping station, and transmission mains for such a project were included as a $50,000,000 item in a $83,000,000 capital improvement program, the financing of which was approved by the voters of Wayne County in April 1955. The firm of Hazen and Sawyer began its work on the survey and study, which culminated in a report on additional water supply for Wayne County.

Following the submission of the Hazen and Sawyer report, the several potential sites were evaluated, and a

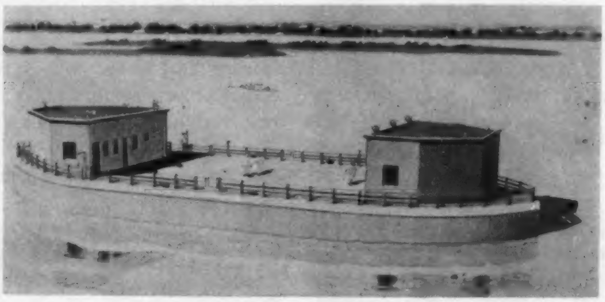

Fig. 1. Wayne County Intake

This architect's drawing is a view looking toward Wyandotte on the American shore, with Grassy Island in the background. Downstream is to the left.

condemnation suit was begun to acquire the site for the filtration plant and pumping station. A site was also acquired at the river for the raw-water tunnel shore shaft.

At the same time it was necessary to secure permits from the Canadian government and from the province of Ontario, the intake site being on the Canadian side of the international boundary. The Department of Public Works of Canada controls all structures in navigable waters and the Ontario Department of Lands and Forests controls the use of submerged lands. It became necessary to lease from the province of Ontario a water lot 300 ft square, covered by about 35 ft of water, one edge of which is the international boundary.

Because the intake and the tunnel constitute a direct physical connection between the United States and Canada, it was required by the conditions of the permit granted by the US Corps of Engineers that Wayne County secure, through the US State Department, a license signed by the President.

In order to develop the site, it has been necessary to clear and grade the land and to relocate a natural drainage channel which cuts across the site, as well as to fill the old channel.

While all this was going on, the functional design of the plant was being developed by the engineers, the intake (Fig. 1) and tunnels were being designed, and a series of borings along the route of the land tunnel and the river tunnel and at the intake site were being made. The land borings went through the overburden and 5 ft into rock; the river borings were cased through the water and then extended through the overburden and 100 ft into rock.

Present Construction

In order to realize as soon as possible some degree of benefit from the capital improvement program funds and to develop as broad a base of water consumers as possible, as well as to have the first stage of the transmission system completed when the filtration and pumping station is ready to deliver water, construction was begun on the transmission system and is currently proceeding.

Eight miles of the Inkster Road main is complete. The Wick Road–Pelham Road Main is in preliminary stages of construction, and the remaining mains will be completed by late 1960.

Another firm was retained to translate the first functional design into working drawings and detailed specifications. This work is essentially completed and ready for final approval prior to advertising for construction bids. On Sep. 11, 1957, bids were received for the raw-water intake and tunnels and the low-lift caisson at the station, and actual construction is expected to begin soon.

Conclusion

In 1949, the average daily consumption by the customers of the Wayne County Metropolitan Water Supply System was 5 mgd; by 1956, the average was 25 mgd. The engineering report predicts that this average use will be 64 mgd in 1960 and 143 mgd by 1980. Wayne County is making progress toward meeting this anticipated heavy demand for water.

—Locating the New Intake—*Francis P. Coughlan Jr.*—

A paper presented by Francis P. Coughlan Jr., Hazen & Sawyer, New York, N.Y.

In 1955 the Board of County Road Commissioners, Wayne County, Mich., investigated the lower Detroit River and the northwest corner of Lake Erie as potential sources of water for an independent supply. Currently most of Wayne County is supplied with filtered water from the city of Detroit's system. The investigation was prompted by the stated policy of the Detroit water board that Wayne County should obtain a separate supply for the lower and western parts of the county. In the interim, the water board's position has changed and there has been considerable controversy, not only about the economics of developing a supply from the lower Detroit River, but also about its water quality. The question faced by Wayne County in 1955, however, was "Could a safe and palatable water supply be obtained from the lower Detroit River, or must the intake be located much further away—at Belle Isle further upstream, or perhaps from Lake Erie, as had been suggested in Detroit water supply studies 30 years ago?" This article describes the unusually complete efforts on the part of Wayne County to determine the best location for an intake.

The Detroit River has an average flow in excess of 190,000 cfs, placing it high among the great fresh water systems in the world. Compared to other rivers, the flow is uniform. Actually, the Detroit River is a strait between lakes and not a river (Fig. 2). In this area of the Detroit River there are three municipal water intakes and five sewage treatment plants. The water intakes are: the Wyandotte intake 5 mi below the Rouge River and extending ¼ mi off the US shoreline; the Monroe intake in Lake Erie, 1 mi off Point aux Peaux; and the Amherstburg, Ont., intake on the river shoreline. A fourth intake, in the Trenton channel, was abandoned in 1943.

Dry-weather sewage flows from the northern half of Wayne County are treated at three treatment plants located along the Rouge River: the two city of Dearborn plants and the city of Detroit plant. The Detroit sewage outfall extends into the Detroit River about 500 ft from shore, just above the mouth of the Rouge River. Treated sewage from the southern half of the country is discharged into either the Trenton channel from Wayne County sewage treatment plants or into the Huron River. Neither Windsor nor Amherstburg have sewage treatment plants.

The principal industrial wastes from Wayne County are discharged into either the municipal sewerage systems, the Rouge River, or the Trenton channel. One chemical plant pumps its spent brine waste waters across the international boundary to lagoons on Fighting Island. The wastes discharged to the Trenton channel flow directly into the northwestern end of Lake Erie.

River Analyses

Seventeen sampling ranges and 85 sampling points were established in the lower Detroit River and Lake Erie. Where possible, the sampling points were established at or between

navigational lights and buoys. Other sampling points, particularly in Lake Erie, were located by operating the sampling boat at a predetermined speed and timing distances from buoys and the shore. In all, 73 sampling trips were made and 4,056 bacteriological samples were obtained in the lower Detroit River; in Lake Erie 35 trips were made and 1,023 samples obtained.

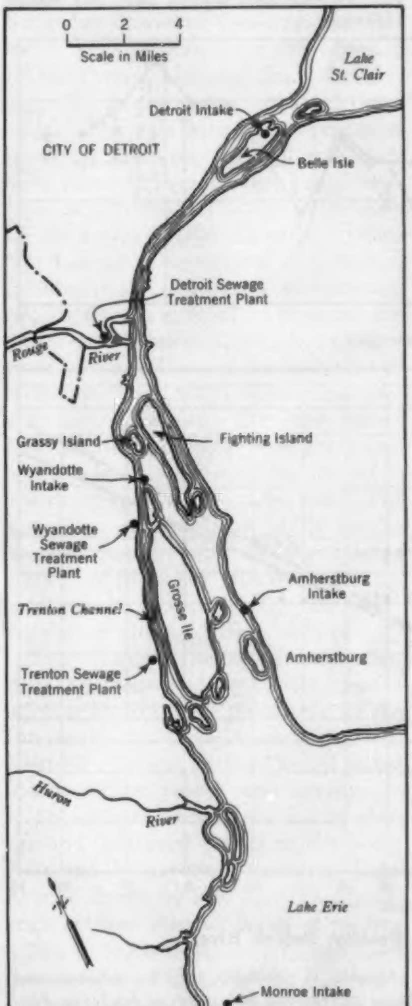

Fig. 2. Detroit River Area

Points discussed in the text are indicated above.

Coliform bacteria and chloride analyses were performed on all samples. The coliform organism test was relied on as an index of sewage contamination, and the chloride test to detect the presence of both sewage and industrial wastes. The Detroit area is underlaid with salt beds. Brine is used extensively as a raw material, and many of the industrial wastes and the Rouge River are high in chlorides. Thus, the chloride test provided a good measure of the spread of sewage and industrial wastes from the Detroit sewage outfall and the Rouge River area.

In addition to these samples, 345 complete chemical analyses, including phenol, cyanide, chromium, ammonia, turbidity and hardness determinations, were made periodically.

Coliform bacteria densities were determined from fermentation in lauryl tryptose broth, with three tubes in each of three decimal dilutions. All survey data were plotted on log probability graphs to indicate the typical coliform organism density and the variations. A typical plot is illustrated in Fig. 3. Depth sampling in sterilized bottles is too time-consuming for extensive sampling, and the bulk of the Wayne County bacteriological samples were dipped from 2 ft below the surface. Previous surveys had indicated a similar coliform organism density in surface and deep waters. Studies in 1955 (Fig. 3) and again in 1956 substantiated the fact that representative samples could be obtained by restricting routine sampling to surface waters. The variations of density in surface and deep water at a buoy on the east

side of the navigational channel opposite Wyandotte, Mich., are presented in the upper half of Fig. 3, and the relative water quality is compared in the lower half. Although the samples showed fairly rapid changes in coliform organism density, statistical analysis indicated no significant difference in overall bacterial quality.

The median, or 50 per cent, value, the 95 per cent value, and the arithmetic mean density were used to summarize the coliform bacteria data. The median and the 95 per cent value

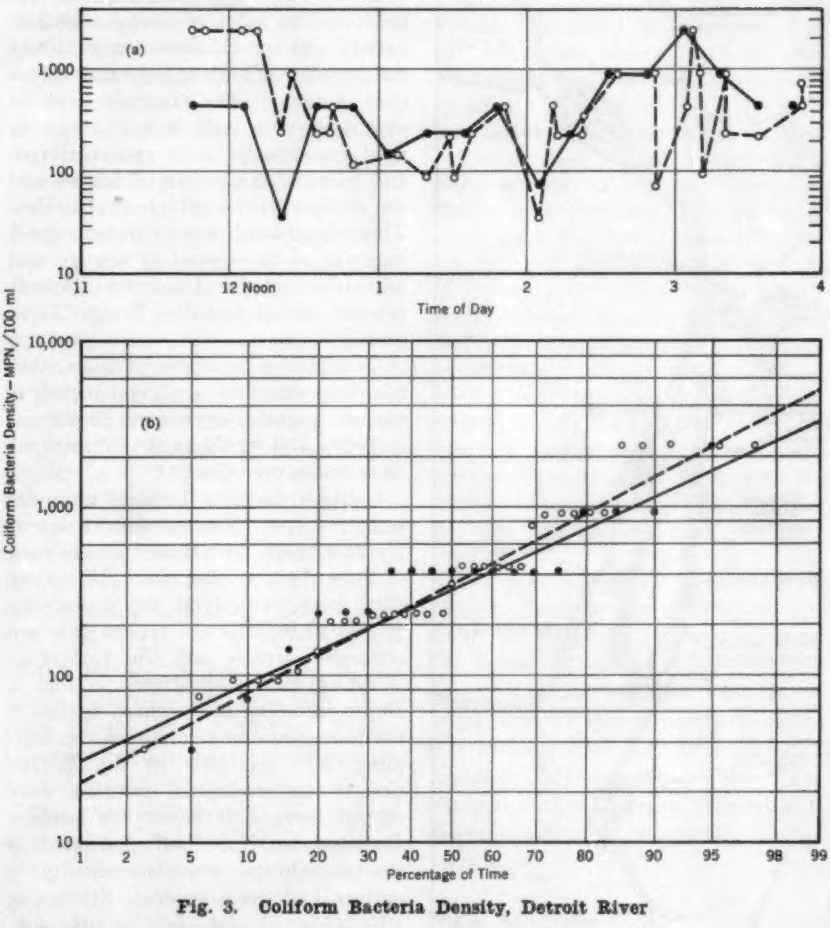

Fig. 3. Coliform Bacteria Density, Detroit River

Data were plotted from a sampling point opposite Wyandotte, Mich., downstream from Detroit, for Oct. 31, 1955. Fig. 3a shows variations in coliform bacteria density; and Fig. 3b, relative water quality of surface and deep-water samples. Solid lines and solid dots represent surface samples; hollow dots and dashed lines, depth samples.

were read directly from the probability graphs. By itself, the median describes conditions on the typical day. It does not reflect the variations, and the median is therefore not an "average" value. The median and the 95 per cent value present a complete, if somewhat unwieldy, two-term parameter. The arithmetic mean density (AMD) was calculated from the median and the geometric standard deviation. The AMD has been proposed by H. A. Thomas, Jr. (*1*) as a one-term parameter of average conditions. It is in effect a statistical expression for the average value of a series of data that follows a log-normal distribution. Although an expression of average conditions was desired to evaluate the public health hazards, simple averages were not used because the inclusion of occasional high MPN values can produce erratic results. The high values may not be representative of the water quality, but due instead to the variations inherent in the tube test. The variations, or scatter, of MPN results can be minimized by seeding a large number of tubes per dilution, but practical considerations usually limit the number of tubes to three or five.

The Wayne County survey data were supplemented by water quality information collected previously by the International Joint Commission in 1946–48 (*2*) and by the Detroit water board in their yearly river surveys.

The extent of contamination by sewage and industrial wastes in the lower river and the northwest corner of Lake Erie is shown in Fig. 4. The boundaries between various zones of median coliform bacterial concentrations and the boundaries between zones of average chloride concentrations have been interpolated from the data and the zones shaded. The white zones represent the cleanest waters and the darkest zones the most contaminated water. The bacteria and chloride distributions are markedly similar in most respects and indicate clearly the following points:

1. The most important sources of pollution are the Detroit sewage outfall and the Rouge River, which enter the Detroit River at the same point. Upstream from the Detroit outfall, contamination is limited to narrow bands along the shorelines.

2. Characterization of the lower Detroit River as the "sewer for Metropolitan Detroit" is not warranted. Heavy contamination is confined to a narrow strip along the United States shoreline from the Rouge River into the Trenton channel. A long tongue of this polluted water extends into Lake Erie. Thus, while the northwest corner of Lake Erie is subject to the waste flows of the entire Detroit area, portions of the Detroit River are partially or fully protected by islands or shoals or are located upstream from local contamination.

3. Mid-river water is of good quality in the upper part of the Detroit River, and a thread of this clean water extends more than 10 mi below the Rouge River.

4. Although the mid-river water does not escape all pollution from the Rouge River, the rate of diffusion of shore pollution towards the center of the main flow is low, and any wastes reaching the center are diluted many times.

5. To get water from Lake Erie as good as mid-river water would require an intake near the Monroe intake or 2–3 mi offshore, near the shipping channel.

The quantities of mid-river water unaffected or partially affected by

shoreline pollution are not readily apparent from shadings on a true scale map. Although the Detroit River channel is relatively uniform above the Rouge River, further downstream it divides into channels, separated by shoals and islands. Most of the water is carried by these deeper channels, and very little passes over the shoal areas. Furthermore, in spite of depths of 25–30 ft, even the deep channels are much wider in relation to depth than is normally realized. For example, the channel between the United States shore and the upper end of Fighting Island is some 2,000 ft wide and 30 ft deep. The opportunity for diffusion and the rate of diffusion of shoreline pollution across the river under these circumstances is much less

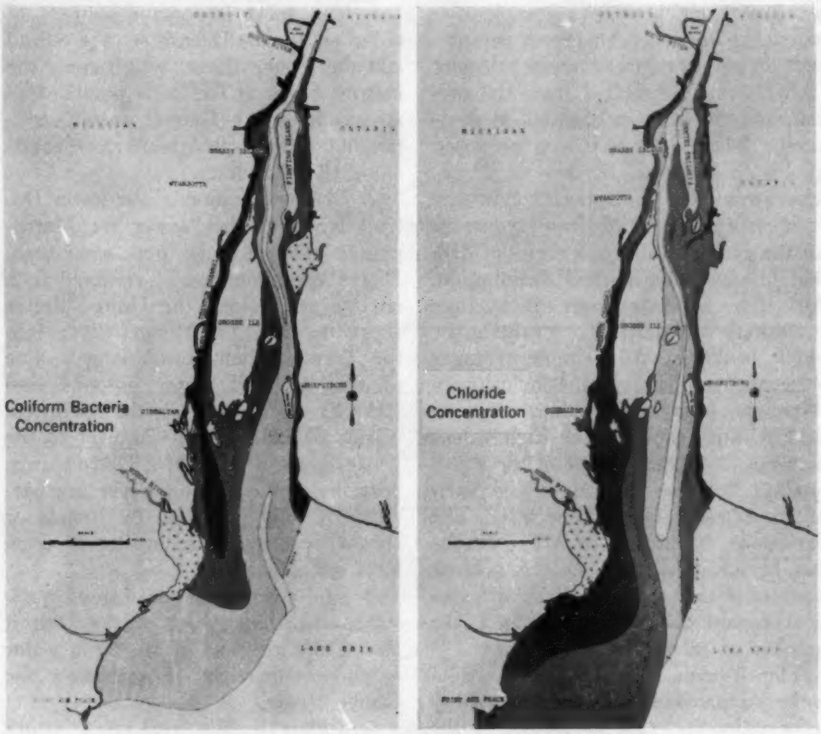

Fig. 4. Concentrations of Coliform Bacteria and Chloride

Maps cover that portion of the Detroit River from where the Rouge River and Detroit sewage enter, to where the river empties into the northwest corner of Lake Erie. Darkest areas show zones of heaviest contamination (for coliform bacteria, a median MPN of more than 10,000; for chlorides, more than 50 ppm). Shades of gray show areas of cleaner water, down to the white zones, where the bacteria density is less than 1,000 median MPN and the chloride concentration is less than 10 ppm.

than it would be in a narrow, deep stream.

The protection of mid-river water is evident when the survey data are arranged schematically, using the AMD method for expressing coliform bacteria values. The sampling points were located with respect to river flow on the basis of hydraulic radius calculations and gagings by the US Lake Survey. Results show protection of mid-river quality by islands shoals, low rates of diffusion down to Grosse Ile. Water acceptable in the USPHS Class III (an average coliform organism density of 5,000 per 100 ml) can be obtained in a 60,000-cfs stream throughout the length of the river.

The marked stratification in the Detroit River is shown in ways other than by bacterial and chemical analyses. Depth float studies, the appearance of silt streaks after dredging operations, and aerial photographs of the diffusion of the silt-laden Rouge River into the Detroit River all demonstrate the streamlining. Figure 5 is an aerial photograph taken by the US Air Force in connection with the 1946–48 studies of the International Joint Commission. Results of discharge of both the Rouge River and the Detroit sewage outfall into the Detroit River are pictured there.

Water Quality

Water quality in the Detroit River is very similar from year to year. For example, profiles of the median coliform bacteria density across the Detroit River at the upper end of Fighting Island have been drawn in Fig. 6 using various surveys from 1946 to 1955. Although there are variations from year to year, the pattern is consistently the same, a sharp drop in density from the shore to the center of the river followed by a rise in density toward the Canadian shore. Undoubtedly, both the physical configuration of the Detroit River and its fairly constant discharge contribute to this similarity.

Winter conditions prevented sampling after November 1955. Such year round data as are available, however, show that in the lower Detroit River, coliform bacteria densities during the summer are about 50 per cent greater than during the winter. Apparently the increased per capita coliform bacteria production during the summer more than offsets the higher die-away rates. Seasonal variations in coliform organism densities are presented in Table 1.

Fig. 5. Aerial View of Detroit River

This photograph shows that portion of the US shoreline where the Rouge River and Detroit sewage outfall empty into the river. Darkest portion of river, at left, shows the area of heaviest contamination.

TABLE 1

*Seasonal Variations in Coliform Bacteria Densities, Detroit River**

Source of Sample	Densities—*MPN/100 ml*			AMD Ratio (Summer to All Year)
	Summer (May–Oct.)	Winter (Nov.–Apr.)	All Year	
Trenton toll bridge				
Median	16,000	9,500	11,000	
95 per cent value	140,000	60,000	110,000	
AMD†	30,000	13,000	22,000	1.36
Wyandotte treatment plant				
Median	7,100	1,500	3,400	
95 per cent value	75,000	15,000	45,000	
AMD†	14,200	2,700	8,100	1.75
Monroe treatment plant				
Median	310	125	200	
95 per cent value	4,000	2,300	2,900	
AMD†	730	440	560	1.30

* Trenton and Wyandotte figures based on 1952–54 study; Monroe figures based on 1951–54 study.
† Arithmetic mean density.

TABLE 2

Comparison of Detroit River and Lake Erie Water

Item	Midstream, Detroit River		Lake Erie
	Opposite Fort Wayne	Opposite Grassy Island	
Coliform bacteria density—*MPN/100 ml*			
Median	240	440	1,000
95 per cent Value	4,700	4,000	14,000
AMD*	980	860	2,900
Chlorides—*ppm*			
Avg	7.5	8.0	24.1
Max.	9.0	17.0	32.0
Turbidity—*ppm*			
Avg	6.4	8.6	6.5
Max.	16.0	18.0	25.0
Phenols—*ppb*			
Avg	1.6	0.7	1.8
Max.	10.0	2.0	9.0
Ammonia—*ppm*			
Avg.	0.07	0	0.22
Max.	0.4	trace	0.5
Threshold odor—*units*			
Raw water	3.8	5.5	10.6†
After chlorination	11.5	9.9	13.7†
Carbon treated	1.6	2.5	4.1†
Required carbon dosage—*ppm*	2.9	2.9	7.4†
Chlorine demand‡—*ppm*	1.0	1.0	1.3†

* Arithmetic mean density.
† Raw-water sample from the Monroe, Mich., filtration plant used.
‡ Application of 2 ppm chlorine for 30 min.

Of the factors that might be expected adversely to affect water quality periodically, little quantitative information is available on flow reversals, navigation, and dredging. There have been twelve times in the last 46 years when strong east winds have raised the lake level in western Lake Erie to an elevation higher than Lake St. Clair. The hydraulic gradient of the river has been reversed for a total of 70 hr since 1911 with the longest reversal, 14.5 hr, occurring in February 1939. There are no data to show actual reversal of flow, and routine samplings at Detroit and Wyandotte, at most three samples per day, have not been frequent enough to detect the effects, if any, of gradient reversal. Uncontrolled dumpings of dredged materials from the Rouge River and other polluted areas would present hazards, but can be prevented by regulation. Sewage from passing ships is of minor importance, because of the certain immediate dilution.

Algae occasionally have clogged the filters at Windsor, but have never been a source of operating difficulty at the Detroit or Wyandotte water plants. Plankton concentrations at the navigational light at the outlet of the Detroit River are similar to those at Belle Isle, indicating the similarity of mid-river water throughout the river. Further south in Lake Erie, however, plankton counts are higher and extremely variable. These sudden and severe plankton growths cause serious operating problems at the Monroe, Mich., treatment plant.

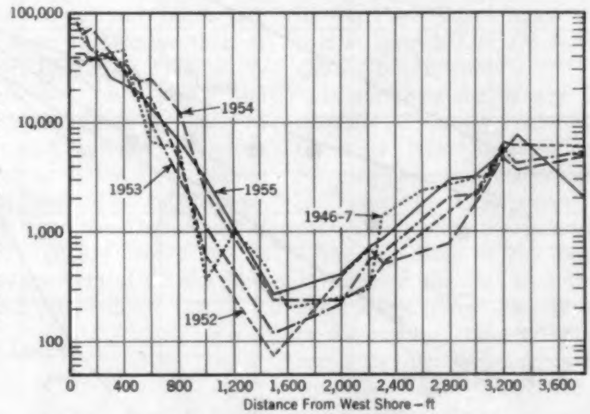

Fig. 6. Coliform Bacteria Densities, 1946–55

Lines are drawn from results of various surveys, as indicated, at one sampling point at the upper end of Fighting Island. Profiles show a consistent pattern, with little variation in bacteria density from year to year.

Particular attention was directed toward the effect of storms and combined sewer overflows on the river water quality. Data from 15 sampling trips on rainy days or on days immediately following rainstorms when adverse effects could be detected, were analyzed. The typical coliform bacteria distribution after a rainstorm were studied together with the general survey data and a comparison of wet-

and dry-weather conditions on the US shore and in mid-river. Results showed that combined sewer discharges do not surge across the river in concentrated slugs. Whatever pollution does reach mid-river is well diluted, and the mid-river water above Grosse Ile remains clean. Further downstream, the effects of storms on quality of the water are more pronounced.

Two general locations in the 85-sq mi area of the Detroit River and Lake Erie investigated by the county were considered of equal bacteriological value. These locations were: mid-river, down to Fighting Island South Light; and Lake Erie, in the vicinity

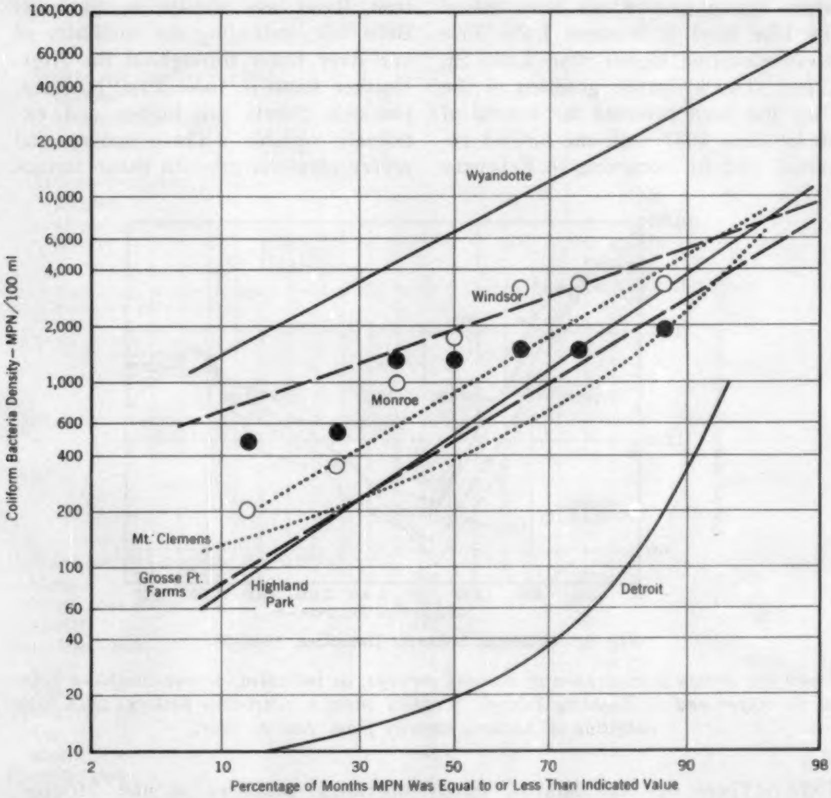

Fig. 7. Comparison of Water at Wayne County Intake With Nearby Water Supplies

The coliform bacteria density of the water at the Wayne County intake is plotted by solid dots for 1955 data and by open circles for 1956 data. Curves, representing water quality at nearby communities as labeled, were plotted from 1954–55 monthly averages.

of the Monroe, Mich., intake. Water from these areas were free from toxic substances, high chlorides, and excessive chlorine demand. Their relative water qualities are presented in Table 2. Both Lake Erie water and Detroit River water, including the Detroit supply at Belle Isle, are subject to occasional tastes and odors from industrial wastes; but Lake Erie water, in addition, is subject to algae blooms and the resultant taste and filter-clogging problems. An examination of operating records and a 3-week special study indicated that tastes and odors are more troublesome at Monroe than at Wyandotte or Detroit. This study also indicated that such tastes and odors as occurred could be handled satisfactorily with present treatment methods. As a Lake Erie supply would cost at least $17,000,000 more than a supply from the Detroit River and the water quality would be no better, the development of a Lake Erie supply was not justified.

Selection of Location

The location of the Wayne County intake in the clean mid-river water was governed by the following considerations:

1. The raw-water quality must be acceptable during usual conditions and must not be subject to shock loads of sewage and industrial wastes.
2. The intake must be located in deep enough water to avoid ice difficulties in the winter.
3. The intake must be accessible for maintenance and repair.
4. The intake must not interfere with shipping and must be able to withstand damage if accidently struck.
5. The intake must be located as near to the center of water consumption as possible.

A submerged crib off Fort Wayne and a tower intake off Grassy Island were considered as the best intake sites. The difference in raw-water quality was negligible, and filtered water would be entirely safe and of excellent quality from either site. The tower intake off Grassy Island was chosen for the Wayne County intake because: [1] a tower intake is accessible for maintenance and repair, while a submerged crib is inaccessible and is more subject to damage from navigation; and [2] a project taking water from a Fort Wayne intake would have cost at least $6,000,000 more than the Grassy Island intake.

Water from the Wayne County intake site off Grassy Island is compared to other local supplies in Fig. 7. Monthly average values were calculated for the 1955 survey data, for comparison with the monthly average figures available on the local supplies. In view of the fact that the coliform densities of river samples are higher in the summer than on a year-round basis, the figure indicates that water from the Wayne County intake is definitely superior to Wyandotte raw water and equal to all other water supplies in the area except Detroit's Belle Isle supply.

The acceptability of a raw-water source, subject to some contamination, is always open for discussion. A pristine source of water is always desirable and within limits outweighs economic considerations. With modern water treatment practices, however, particularly pre- and postchlorination, moderate contamination in a raw water can be tolerated without public health hazards. The experience of many utilities in treating difficult waters successfully has prompted the USPHS to review its 25-year-old recommended

quality standards for sources of water. In any event, water from the Wayne County intake off Grassy Island falls well within the USPHS Class III requirements for water sources treatable by chlorination and filtration.

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1. THOMAS, H. A., JR. Statistical Analysis of Coliform Data. *Sew. Ind. Wastes*, 27:212 (1955).
2. Pollution of Boundary Waters. Report of the International Joint Commission, United States and Canada (1951).

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Supplemental Water for the San Francisco Area

William L. Berry and Herbert A. Howlett

A paper presented on Oct. 30, 1957, at the California Section Meeting, San Jose, Calif., by William L. Berry, Chief, Div. of Resources Planning, and Herbert A. Howlett, Supervising Hydr. Engr., Dept. of Water Resources, Sacramento, Calif.

If it were possible to deport 15,000 people from the Livermore Valley, 90,000 from Alameda County, and 250,000 from Santa Clara County, and, with the departure of these people, to eliminate the industrial and commercial enterprises which they support, this would be one way, admittedly drastic, to overcome the present water shortages of the San Francisco Bay area. To adopt this method, it would also be necessary to barricade the area and put a stop to further growth, either in population, industry, or irrigated agriculture, to prevent the recurrence of water-deficient areas.

Although this is obviously not the solution, it is worthy of note that essentially all further expansion within the San Francisco Bay area, whether it be in population, industry, or irrigated agriculture, must be accompanied by its appropriate amount of imported water.

The current population growth of the nine bay counties is at a rate of about 100,000 people per year. This annual expansion, including the industrial and commercial enterprises which it supports, requires an annual increase in water supply of about 20,000 acre-ft. If this new water supply were to be brought in by railway tank cars, as one community in California is now served, a daily water train consisting of over 1,000 tank cars would be required—a daily train approximately 8 mi long.

The bay area is fortunate to have had among its leaders many far-sighted people who have planned well to meet the water demands of the future. Because of this fact, many of the more highly developed localities around the bay already have facilities to meet the water requirements of their potential service areas for years to come. The question remains: "How can all areas be provided for, anticipating probable substantial population and economic growth in the future?"

The San Francisco Bay area, as discussed herein (Fig. 1), consists of the drainage basins tributary to San Francisco, San Pablo and Suisun bays, downstream from a point about midway between the cities of Pittsburg and Antioch. It also includes those watersheds which drain directly to the Pacific Ocean from Pescadero Creek, approximately 40 mi south of San Francisco to Lagunitas Creek, which enters Tomales Bay about 30 mi north of San Francisco. The uncontrolled runoff from streams within the bay area enters saline bays and is lost to further beneficial uses. The dividing line between the Central Valley area and the San Francisco Bay area, near

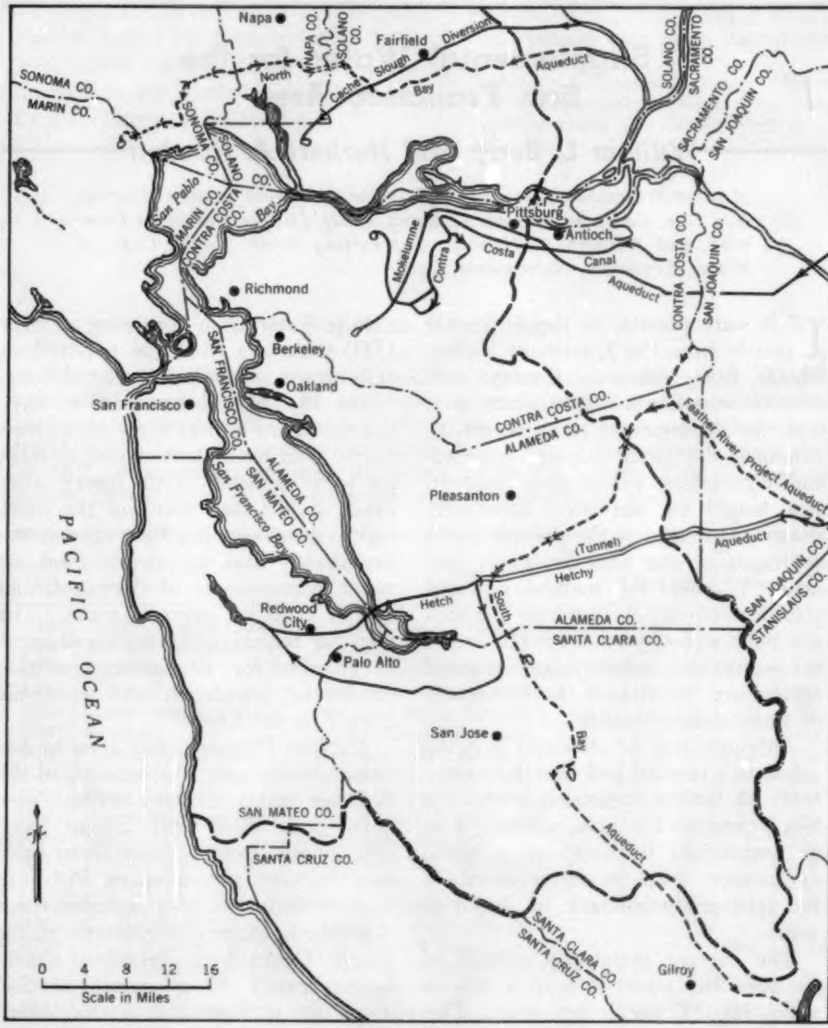

Fig. 1. San Francisco Bay Area

Portions of the area discussed in the text are shown above, outlined by the heavy dashed line. Existing facilities, such as aqueducts and canals, are indicated, as labeled, by solid lines; proposed facilities, by short dashes.

Antioch, is also roughly the dividing line between water of usable and unusable quality in the Sacramento River. The saline bay waters further divide the whole bay area into a south bay area and a north bay area.

The problems associated with supplying supplemental water to sustain and continue the growth of the south bay area are basically the same as those of the north bay area. A difference, however, does lie in the present development, both of communities and water resources.

South Bay Area

The south bay area contained an estimated population of approximately 2,300,000 in 1950, and about 150,000 acres of irrigated land. Although some new land has been brought under irrigation since that time, some has become urbanized, so it is probable that a net decline in irrigated acreage has occurred.

It is predicted that in 50 years the population of the south bay area will reach 5,500,000 and, due to encroachment of this extensive urbanization, the irrigated acreage will decline to 40,000 acres. These predictions, of course, cannot be fulfilled without a dependable water supply. The area is presently served water from ground water basins, from local surface storage works, and by three import systems.

Ground water basins exist within the bay area portion of each of the south bay counties. Those in Contra Costa County have a relatively small yield and are presently fully developed. In the Livermore Valley and the southern portion of Alameda County, the ground water basins are already overdrawn. Sea water threatens to invade and reduce further the usefulness of the basin in southern Alameda County.

In the northern part of Santa Clara County, that portion of the ground water basin adjacent to San Francisco Bay is also being excessively pumped and is drawing water from under the bay. Continuation of this practice could prove to be disastrous if it were to bring salt water into the aquifer. The ground water basins in San Mateo County are being used to their full potential.

Like the ground water basins, runoff from surface streams throughout the south bay area has been nearly fully developed. Such agencies as the city of San Francisco, the East Bay Municipal Utility District, the Santa Clara Valley Water Conservation District, and the San Jose Water Works are to be commended for the high degree of conservation of surface waters which they have accomplished. Relatively few streams remain which offer suitable sites for further storage and regulation of stream flow.

It is estimated that the present safe yield of local water resources of the south bay area, both surface and underground, is about 334,000 acre-ft per year.

Present Aqueduct Systems

In addition to the water developed from local sources, three aqueduct systems bring water to the south bay area from the Central Valley of California: the Contra Costa Canal, the Mokelumne River Aqueduct, and the Hetch Hetchy Aqueduct. These works are presently capable of conveying over 550,000 acre-ft of water per year into the bay area and are importing currently approximately 300,000 acre-ft annually.

The Contra Costa Canal was built by the US Bureau of Reclamation as a feature of the Central Valley Project. This system of works serves the heavy industrial portion of Contra Costa County, which borders Suisun Bay between Martinez and Antioch. The canal is designed for a capacity of 350 cfs, but is limited by installed pump facilities to 310 cfs. At its point of entry into the San Francisco Bay area, the canal has a capacity of 269 cfs. Studies indicate that the Contra Costa Canal is capable of transporting about 146,000 acre-ft of water to the bay area annually without additional regulatory storage. In 1956, however, only 46,000 acre-ft of water were diverted from the delta into the canal.

The East Bay Municipal Utility District has developed the Mokelumne River with Pardee Dam and Reservoir, under terms of a water right permit from the state of California. This permit authorizes the district to divert up to 224,000 acre-ft of water per year from the Mokelumne River and to convey it to its service area. All of the storage works necessary to develop this water have been constructed, as well as the works necessary to convey it to the place of use. Approximately 122,000 acre-ft of water were imported to the San Francisco Bay area through this system in 1955. The district has plans for further storage facilities on the Mokelumne River, and has recently been

Fig. 2. Cherry Valley Dam

Completed in 1956, this dam is the most recent addition to San Francisco's storage facilities.

granted a water right permit authorizing the exportation of an additional 140,000 acre-ft of water annually.

The city of San Francisco proposes eventually to import up to 448,000 acre-ft of water annually to the bay area from the Tuolumne River, by means of expansion of its Hetch Hetchy system (Fig. 2). At the present time, the city's storage reservoirs are capable of developing 291,000 acre-ft annually, and the Hetch Hetchy Aqueduct in its most restricted spot is capable of an annual delivery of about 184,000 acre-ft of water to the bay area. A major portion of the aqueduct could now deliver the full 448,000 acre-ft, however, and the 28-mi coast range tunnel is capable of delivering some 280,000 acre-ft annually. The importation to the bay area during the 1954–55 water year was 123,000 acre-ft. The Raker Act, under which Congress authorized the city to construct storage facilities within the boundaries of Yosemite National Park, prohibits use of the conserved water for irrigation purposes. While the place of intended use of Hetch Hetchy water has not been specifically defined, it has been reasonably well established through sales made during past years. Primarily, the service area is within the city and county of San Francisco and in San Mateo County. The city also sells water in Santa Clara and Alameda counties, however, and has publicly stated its willingness to continue to serve large portions of these counties in the future.

In summary: The south bay counties contain both areas of water plenty and areas of water deficiency. The areas of plenty are within the boundaries of agencies which have planned for the future. These include the East Bay Municipal Utility District and the Contra Costa County Water District, the distributing agency for water from the Contra Costa Canal. Customers of the city of San Francisco can also feel sure of a continued adequate water supply for urban uses. Water supply deficiencies, however, do exist in Livermore Valley, the southern portion of Alameda County, and the northern portion of Santa Clara County. Unfortunately, these are the areas which are expected to experience the largest population growth during the next 50 years. Being contiguous, however, these areas lend themselves to solution of their water supply problems by a single project of mutual benefit. The project developed by the state to accomplish this purpose has been entitled the South Bay Aqueduct.

South Bay Aqueduct

The South Bay Aqueduct, a feature of the state-authorized Feather River Project, would divert water from the Feather River Project Aqueduct on the west side of the San Joaquin Valley. The latter aqueduct, in turn, would receive its supply from the Sacramento-San Joaquin delta to the north, the supply consisting of present flows in the delta, firmed by operation of Oroville Reservoir on the Feather River in the Sacramento Valley. Water for the South Bay Aqueduct would be pumped and discharged into a canal leading to a tunnel through the Mount Diablo Range near Brushy Peak. The aqueduct would then follow along the eastern and southern sides of Livermore Valley as a concrete-lined canal, with reaches of pipe, to a tunnel through the hills southeast of Pleasanton (Fig. 1). From this tunnel, the water would be conveyed in a pipeline to a third tunnel at Mission Pass. At the end of the Mission Pass Tunnel the aqueduct would swing

south and follow the base of the hills along the eastern side of the Santa Clara Valley. Water would be pumped from the aqueduct into a regulating reservoir east of Milpitas and another southeast of San Jose. The South Bay Aqueduct, as authorized, would terminate in San Benito County at a point approximately 40 mi south of San Jose. It is estimated that the cost of the aqueduct would be about $60,000,000.

In 1956 the legislature appropriated about $3,500,000 for preparation of construction plans and specifications for the South Bay Aqueduct and purchase of the regulating reservoir sites. Since completion of the planning studies which led to authorization of the aqueduct, significant changes have taken place in the proposed service areas. It was originally planned that the water would be served in the southern portion of Santa Clara County in the vicinity of Gilroy and to San Benito County. Further studies disclosed, however, that local supplies can be developed to provide water to meet the ultimate requirements of the southern portion of Santa Clara County, and local agencies are diligently constructing works to make this an accomplished fact. In view of this, consideration is now being given to another project which would supply water to San Benito County from the proposed San Luis Reservoir west of Los Banos. Under this alternative, the South Bay Aqueduct could be terminated in the northern portion of Santa Clara Valley. These studies are still in process.

It is anticipated that construction plans and specifications for the South Bay Aqueduct will be completed in 1959. It will be necessary either for the legislature to appropriate funds for construction of the facilities or for the local area to finance the construction. While a state financing policy has not yet been adopted, a partnership arrangement might be devised whereby the state would develop the plans and specifications for the project in accordance with the California Water Plan and donate them, together with the land, easements, and rights of way, as its contribution to the local area. The local area, in turn, would finance the actual construction and construct, operate, and maintain the facility.

Completion of the South Bay Aqueduct, together with necessary distribution facilities, would overcome all present water supply deficiencies in the south bay area, and provide sufficient capacity to meet demands anticipated during the coming 50 years. The probable water demands of the next century will have to be reanalyzed at some appropriate future date, and additional facilities designed to meet the then current situation.

North Bay Area

The north bay area, for purposes of this article, includes the Fairfield-Cordelia plain together with the adjacent marshland, the Napa Valley, the Sonoma Valley, the Petaluma Valley, and the southern portion of Marin County (Fig. 1). In 1950 this area had an estimated population of 254,000, as contrasted with 2,300,000 for the south bay area. There were 13,000 acres of land under irrigation.

While the general trend of development in the south bay area has been fairly well established, the pattern for development of the north area remains to be formed. There can be little doubt but that the lack of a dependable water supply has been among the principal deterrents to growth in the north bay counties. During the next 50 years, however, the area may be

expected to blossom into a closely knit community with a population of over 1,300,000. Studies indicate that over 200,000 acres of irrigable land in the north bay area remain undeveloped, due largely to the lack of a water supply. More than one-half of this acreage lies on the flat plains bordering the bays at elevations of less than 50 ft. It is estimated that about 65,000 acres would be under irrigation in the year 2010, if reasonably priced supplemental water were available.

The local water sources available in the north bay area are more limited than in the south bay area. The ground water basins are of small capacity and have firm yields estimated to total less than 20,000 acre-ft annually. These basins are already fully developed, and in localized areas sea water intrusion threatens.

Likewise, the opportunities for conservation of surface runoff are fewer in the north than in the south bay area. Those reservoir sites which offered the greatest amount of storage capacity and yield have already been developed, and those that remain are costly in terms of acre-foot of yield. As in the south bay area, farsighted individuals and agencies have provided the water needed to support the development to date, but as is the situation in many other parts of California, further expansion must rely primarily on an imported water supply.

At this time, the north bay area has only one water import system, that of the city of Vallejo. Vallejo has a pumping plant which diverts water from Cache Slough in the Sacramento-San Joaquin delta north of Rio Vista, and a pipeline to convey the water to users within its boundaries. This system has the potential of importing about 23,000 acre-ft of water each year. Pipeline limitations, however, do not permit this amount to be delivered all the way to Vallejo, and to date the system has only been operated to about one-half of its capacity.

Current Projects

The US Bureau of Reclamation is now completing the Solano Project. This project includes a dam across Putah Creek, west of the town of Winters, to create a 1,600,000 acre-ft reservoir, and a concrete-lined canal to convey the stored water to potential service areas within Solano County. The Fairfield-Cordelia portion of the north bay area will receive supplemental water from this project—approximately 55,000 acre-ft per year.

A second federal project, now under construction, could provide a limited amount of much needed supplemental water into the north bay area. This is the Coyote Valley Project of the US Corps of Engineers, located on the east branch of the Russian River near Ukiah, approximately 60 mi north of Santa Rosa. When completed, water from this project will be released into the river channel to be rediverted and delivered to downstream consumers. The principal distributing agent for Coyote Valley water will be the Sonoma County Flood Control and Water Conservation District. The district has plans for diverting the water from the Russian River through a system of radial collector wells to deliver potable waters to the city of Santa Rosa, communities in Sonoma Valley, the city of Petaluma, and possibly to wholesale customers in Marin County. Therefore, some Russian River water may enter the San Francisco Bay area as a domestic or municipal supply. It probably could not be economically used, however, for agricultural purposes.

It has been estimated that the north

bay area will require about 300,000 acre-ft of water annually by the year 2010, in addition to presently available supplies, including that from the Solano Project. The urgent need for supplemental water is imminent in portions of Sonoma and Marin counties. In planning to meet the problem, those parts of the California Water Plan designed to serve water to the area were reviewed, to select the most economic project that would serve the purpose during the 50-year period beginning in 1960. Possible projects on the Eel River, abutting the Russian River watershed on the north, were found to be very expensive if designed to meet the needs of the north bay area alone, and insufficient data existed to predict the time at which other water demands of California would justify their construction. Waters of the Putah Creek basin are already being developed by the Solano Project. With the completion of that project, the exportable water supply of Putah Creek will be put to use within Solano County and will not be available for Napa, Sonoma, and Marin counties.

The initial stage of the Coyote Valley Project will be capable of meeting the water needs in the Russian River basin until about the turn of the century. As has been indicated, water from this project could also be exported to the Petaluma and Sonoma valleys and Marin County. The cost of this water, however, probably would not permit its use for irrigation in the lower Petaluma and Sonoma valleys.

The additional local projects which might be constructed within the San Francisco Bay drainage portion of the north bay counties would develop only relatively small quantities of water. Two of these, however, the Nicasio Project in Marin County and the Spring Valley Project near St. Helena in Napa County, probably should be considered for construction by local agencies.

North Bay Aqueduct

The proposed North Bay Aqueduct would be fully capable of delivering sufficient untreated water from the Sacramento-San Joaquin delta to meet the supplemental water demands of the Fairfield-Suisun marshlands, Napa, Sonoma and Petaluma valleys, and portions of Marin County during the period from 1960 to 2010. This aqueduct could obtain its water from unregulated supplies now available in the delta, supplemented by water purchased on an interim basis from either the Central Valley or Feather River projects until other facilities are constructed. Such a coordinated plan of operation would lend financial support to the Central Valley Project, or to the Feather River Project, while their service areas are being developed. Upon completion of another project, a portion of its yield could be specifically assigned to the aqueduct.

The North Bay Aqueduct would divert water from Lindsay Slough in the Sacramento-San Joaquin delta, and convey it as far west as Novato in Marin County, a distance of 59 mi. The aqueduct would have an initial capacity of 900 cfs. It would contain two pumping plants, one at the point of diversion with a lift of 15 ft, and the other near Cordelia with a lift of about 100 ft. The aqueduct would consist of an unlined canal between these points. The remainder would include a 3-mi tunnel, a concrete-lined canal, and lengths of pipe to cross Napa, Sonoma, and Petaluma valleys.

The aqueduct would terminate in a small reservoir with a normal water service elevation of 32 ft, near the town of Novato.

The North Bay Aqueduct would cost approximately $27,000,000. Its full capacity of about 300,000 acre-ft per year would meet the requirements of the year 2010. The aqueduct would be a trunk facility only, and was designed on the premise that treatment, as needed, and distribution would be conducted by local distribution agencies.

The North Bay Aqueduct was the only major new water project authorized by the 1957 regular session of the California legislature. Funds in the amount of $1,340,000 were appropriated for preparation of construction plans and specifications for the project. The problem of financing construction of the North Bay Aqueduct, however, is parallel to that of the South Bay Aqueduct; either the state legislature must appropriate funds for construction, or the local area must underwrite the cost of the project. In the latter situation, the north bay area does not now contain a public entity with the powers necessary for financing the system, and it would probably be necessary for the several civic bodies to form an appropriate type of district. If the legislature continues to provide funds necessary to carry the project forward, the water problems of the north bay area for the next 50 years could be solved by the year 1961—the possible date of completion of the North Bay Aqueduct.

Summary

Fifty years hence, the San Francisco Bay area may contain a population of 6,800,000. By 1980, irrigated agriculture in the area will probably have passed its peak and be on the decline, with about 108,000 acres still under irrigation in the year 2010.

The local surface water resources of the San Francisco Bay area are nearly fully developed, and nearly all ground water basins are either in full use or being overdrawn. The annual water requirements of the area in the year 2010 will probably exceed 1,500,000 acre-ft, as compared to an estimated 1960 requirement of about 900,000 acre-ft.

The supplemental water needed in the San Francisco Bay area during the next 50 years can be supplied from local sources, from expansion of present import systems, and from two authorized but presently unconstructed projects, the North Bay Aqueduct and the South Bay Aqueduct. Successful operation of both of these new aqueducts will be dependent upon continuing construction of water storage projects capable of maintaining a firm and dependable water supply at their points of diversion in the Sacramento-San Joaquin delta. A means of financing the cost of constructing the North Bay and South Bay aqueducts must be found. This could be either at the state or local levels, or on a partnership basis.

Fifty years ago, officials of San Francisco certainly did not foresee atomic power, jet airplanes, or high-finned automobiles. They did, however, have faith in the future of the bay area. They foresaw the imperative need for a dependable water supply, they planned well, and they took positive action in the interests of the future.

Iron and Manganese in Water Supplies

Thomas M. Riddick, Norman L. Lindsay, and Antonio Tomassi

A paper presented on Sep. 12, 1957, at the New York Section Meeting, Upper Saranac Lake, N.Y., by Thomas M. Riddick, Cons. Engr. & Chemist, Norman L. Lindsay, and Antonio Tomassi, all of Thomas M. Riddick & Associates, New York, N.Y.

BOTH iron and manganese are highly objectionable constituents in finished water, either for domestic or industrial usage. Iron is present in varying degrees in practically all reservoir waters throughout the United States, and it is particularly manifest in the bottom waters of the zone of stagnation. In general, manganese occurs to a lesser extent in waters along the northern Atlantic Seaboard, and its concentration in reservoir waters more often approximates one-third to one-half the concentration of iron. The allowable limits of iron and manganese combined in finished waters, is set by the US Public Health Service at 0.3 ppm. This is a reasonably conservative figure, however, and except for certain industrial processes, a higher limit, such as 0.5 ppm, may often be tolerated. The pulp and paper industries find that *any* iron or manganese (0.1 ppm or less) is objectionable, since both of these constituents are readily adsorbed by pulp fibers, resulting in a loss of brightness from iron and a detectable blackish mottling from manganese. It is factual, however, that a great many pulp and paper mills do operate with iron and manganese concentrations equaling or exceeding 0.3 ppm. From the domestic consumers' standpoint, iron and manganese are objectionable, since they destroy brightness in and impart a brownish color to laundered goods and appreciably impair the taste of beverages, including coffee and tea.

Iron Concentrations

In certain parts of North Carolina, the concentration of iron in ground water is 2–5 ppm. This is almost entirely in solution, made possible by the presence of 30–50 ppm of carbon dioxide. A glass of freshly drawn water, therefore, contains only a trace of colloidal turbidity. If the water stands overnight, however, the uptake of oxygen and release of carbon dioxide result in a continued drop-out of iron, as it is oxidized from ferrous bicarbonate to ferric hydrate. Thus, a freshly drawn sample, though reasonably acceptable from the standpoint of turbidity, becomes highly unacceptable after a period of several hours.

There seems to be little correlation between visual geological manifestations of iron on the watersheds and its occurrence in reservoir waters from such drainage areas. For instance, the Ringwood area near Suffern is the site of one of the early commercial iron mines in New York State; from this mine the iron was produced for forging a chain which blocked the Hudson

River to enemy ships during the Revolutionary War. Although there is a known condition of underground ores high in iron, they are not reflected in surface or well waters from this area. At Bethel, Conn., there are two developed watersheds, practically adjacent, with the reservoir waters of one being relatively high in iron, whereas in the other, iron is relatively low. The area immediately north of Ossining, N.Y., is particularly unfavorable from the standpoint of developing a satisfactory ground water supply. In this section the earth overburden is light and practically all wells are sunk from 100 to 300 ft in rock. About 50 per cent of the rock wells in this area yield a water comparatively free of iron, whereas the iron concentration in the remaining wells varies from about 1 to 5 ppm, rendering these waters unacceptable for domestic use. There does not seem to be any pattern whereby good or bad wells in this area may be predicted, and quite often by moving several hundred feet away from one site, a well water free from iron may be obtained, as contrasted with heavy iron concentrations at the site in question.

The dissolved-oxygen concentration of well waters high in ferrous iron is more often relatively low, being in the range of 5–40 per cent of saturation. It seems quite probable that water from such rock wells is derived from more than one fissured vein, and it is likely that water in the vein containing the iron contains no oxygen at all. If this is the situation, it follows that another vein feeding this well will contain little or no iron, but will be relatively high in dissolved oxygen. These conditions of combining two different types of water underground often result in water that is practically clear upon withdrawal from the well. Such water, however, will often precipitate a sizable portion of the iron upon standing several hours, even if a sample is collected without aeration and kept in a stoppered glass bottle filled to overflowing. Since most small well supplies are discharged to pressure tanks, where rapid aeration is effected due to the air cushion in the top portion of the tank, it is inevitable that such waters will be discharged from the tank with a sizable amount of precipitated iron, generally in a colloidal state.

In general, the iron concentration of gravel wells is less than that from rock wells. This is due to the fact that gravel wells often draw from a single aquifer rather than multiple aquifers, and that colloidal or precipitated iron, if formed, is removed by underground filtration.

Where reservoir water high in iron is to be processed through a competently designed water treatment plant, including aeration, coagulation, flocculation and filtration, it is seldom that any difficulty ensues due to iron as such. Aeration readily oxidizes ferrous bicarbonate from the soluble form to ferric hydrate, and the hydrate, though present even in colloidal sizes, is readily adsorbed and absorbed by conventional flocs produced by the reaction of alum or any of the ferric coagulants. The application of sufficient alum to remove color and produce a satisfactory floc is generally sufficient to remove iron completely.

Manganese Concentrations

Manganese, on the other hand, may be extremely difficult to remove in a standard type of water treatment plant under conditions of conventional treatment. Whereas iron is readily oxidized to an insoluble state by aeration, man-

ganese undergoes no such oxidation within the time limit afforded by spray or forced-draft aeration. Manganese is readily removed by adding sufficient lime to treated water between the sedimentation and filter basins to raise the pH to a range of 9–10. On the other hand, the raising of alum-treated water to such a high pH range generally results in peptizing a sizable proportion of the alum floc carried over from the sedimentation basins, and such peptization results in a passage of alum through the filter, to precipitate later in dead ends on the distribution system. Thus, the operation can be successful, but the deleterious aspects occasioned by alum passage may be almost as severe as that which would have ensued if the manganese had not been removed. At most water utilities, the presence of manganese can be readily detected without employing standard methods of water analysis. If water containing more than about 0.2 ppm of manganese is employed for operating either chlorinators or dry-chemical lime feeders, a brownish precipitate immediately forms and gives visual indication of the presence of manganese. It can therefore be said that manganese can be removed by conventional treatment plants, but only with some impairment of the quality of the finished water.

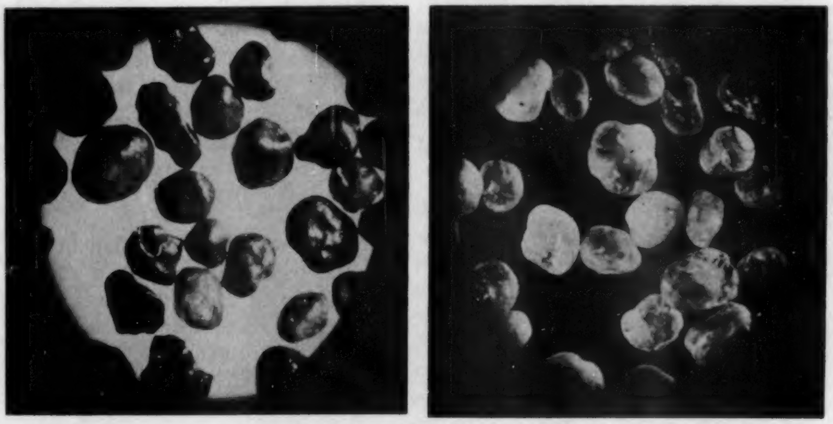

Fig. 1. Manganese-Coated Filter Sand

Both samples are of the same sand—before (left) and after (right) a cleaning with hot hydrochloric acid. Blackness of the particles is due primarily to the presence of manganese, although some iron is present. Magnification in these microscopic photographs approximates 40×.

Although manganese is difficult to oxidize by atmospheric oxygen, it is readily oxidized by chlorine if dosages in the range of 5–10 ppm are applied and if chlorine residuals of 2–3 ppm are maintained. This, of course, constitutes the excess-chlorine type of treatment, and both iron and manganese are oxidized to an insoluble state. These compounds are then removed by the

filter through mechanical straining (being enmeshed in the floc) or by forming a coating on the filter sand. It does not require more than about 0.1 ppm of manganese when so oxidized to coat partially most sand particles with a black precipitate of manganese (Fig. 1). If this coating were continuously built up, there would be danger that the sand particles would increase appreciably in size or possibly become cemented into ball-like masses. If the rate of backwash, however, approximates that required for a 50 per cent sand expansion, it will be found that coatings do not build up, which leads to the inference that such coatings must be daily removed by mechanical attrition during the backwash process.

Control and Removal

It may therefore be said that iron and manganese can be effectively controlled in a well designed water treatment plant where provisions exist for aeration, coagulation, sedimentation, and filtration, and where chlorinating capacity is adequate for applications of 5–10 ppm. Heavy chlorine dosages of this magnitude, however, definitely require dechlorination, and provision must also be made for continuously applying such a reducing agent as sodium metabisulfite or sulfur dioxide to lower the chlorine residual of the plant effluent to a range of 0.3–0.5 ppm. It is also necessary with the excess chlorine treatment process to provide copious aeration to release the nitrogen trichloride and other byproducts formed by the reaction of chlorine with organic matter. If spray aeration only is available, then spray pressures should be a minimum of 10 and preferably 15–20 psi. A better solution to the aeration problem is to employ a rectangular basin with a detention of 15–30 min and to secure aeration by forced draft, employing carborundum diffuser tubes or plates or other devices to secure proper release of air.

Iron and manganese are extremely difficult to remove by low-cost methods from an otherwise clear and acceptable well water. Both of these constituents are satisfactorily removed by the conventional ion exchange softening process, if appropriate exchange media are employed. If the water is relatively soft, however, and does not require further softening, then ion exchangers may be employed for removal of iron and manganese only. Such installations, however, are relatively expensive as well as being space consuming. Also, operating expenses are almost comparable to those of conventional rapid sand filtration plants.

A relatively inexpensive method for reducing the ill effects of iron and manganese in otherwise acceptable well waters is the employment of sequestering or chelating compounds. One of the outstanding recent books on chelation (*1*) defines it as follows:

> When a metal ion combines with an electron donor, the resulting substance is said to be a complex, or coordination, compound. If the substance which combines with the metal contains two or more donor groups so that one or more rings are formed, the resulting structure is said to be a chelate compound, or metal chelate, and the donor is said to be a chelating agent.

It is interesting to note that the book, though most outstanding on chelation, fails entirely to tie this in to the very practical field of water treat-

ment, and the complexity of the chemistry is such as to discourage many from attempting this translation.

Use of Polyphosphates

From a practical standpoint, however, it may be said that a number of compounds, including the glassy polyphosphates, do have the property of sequestering both iron and manganese —that is, combining with them to form complex compounds which tend to remain in solution, rather than being precipitated by dissolved oxygen or other oxidizing agents. One such glassy polyphosphate on the market which has received rather continuous publicity through advertising and through technical articles is sodium hexametaphosphate. If applied in proper dosages to well waters before any initial precipitation of iron or manganese, it tends to hold these constituents in solution up to and often past the consumer's tap. Sometimes such suppression will not withstand the rigors imposed by, for example, boiling the water in a tea kettle, and sometimes this sequestering action deteriorates even in domestic water heaters. On the other hand, it is definitely a delaying, and for many water utility uses, an inhibiting action that is worthy of consideration. It is essential that the iron and manganese be completely in solution at the time of applying any sequestering agent. Unfortunately, there are many places where well waters show evidences of precipitation immediately upon being withdrawn from the well, and there the sequestering action cannot be completely successful.

The glassy polyphosphates in all trade literature and in a sizable amount of technical and semitechnical literature are also highly extolled as corrosion-inhibiting agents, and it seems to make little difference to the purveyors of these chemicals whether the water is by conventional standards relatively corrosive or relatively noncorrosive. In other words, the presence or absence of sulfates, chlorides, and bicarbonate alkalinity seems to be (according to the literature) of little concern; also pH is of little or no concern, with perhaps low pH values being on the credit rather than the debit side. Such literature is to be viewed with skepticism or even suspicion, as the cost of pH control plus the cost of polyphosphates raises the cost of such treatment to a point considered by some to be slightly prohibitive. The author believes that there is no such thing as corrosion prevention, and even the expression "inhibiting corrosion" becomes somewhat of a travesty when used in connection with pipelines which have undergone a number of scrapings with pipe-cleaning mechanisms. Unfortunately, experiences such as these do not often appear in public print. This is not meant to be a criticism of polyphosphates, for when a pipeline tuberculates to the extent of requiring yearly cleaning, occasioned by a drop of flow coefficient from a Hazen-Williams value of 125 to about 70–90, the situation can only be considered entirely out of hand, and the only effective remedy is to line the pipe or to replace it with either cement-mortar-lined cast-iron or asbestos-cement pipe.

Another frequently overlooked aspect in the use of polyphosphates is that even in exhaustive technical treatises on the subject, the vendor generally fails to report the stimulating effect of polyphosphates upon algae in reservoir waters exposed to sunshine. Yet this effect is quite positive. In fact, algae production is a great deal more assured than corrosion inhibition.

At the Ossining, N.Y., 12-mil gal, clear-water storage reservoir the application of polyphosphates to the finished water, for even a few months duration, stimulated growths to a point where algae could not be controlled for a period of 1–2 years even after the discontinuance of polyphosphate application. Whereas copper sulfate dosages of 20–50 lb had previously been effective, dosages of even 1,000 lb would not control algae for periods of more than a few days.

Problems of Buildup

Both iron and manganese are capable of buildup in pipelines with no immediate deleterious aspects other than a constriction of flow. Pipelines can be heavily tuberculated with iron in the form of black magnetic oxide and the highest oxidized form, ferric oxide, and still deliver a water with little or no iron pickup. Manganese sometimes builds up on otherwise clean pipe walls or adheres to concrete or other surfaces of water storage basins. More often such manganese is highly crystalline in form, and there is little doubt but that these crystals serve as a catalytic surface for further crystal growth. Where such growths are found they may often be a ½-in. or more in thickness, adhering to smooth-walled pipe. Closely adjacent pipe sections, however, may show no crystalline growth whatever. Such sporadic growths exist in the Nyack, N.Y., distribution system and they were partly removed about 10 years ago when superchlorination was instituted. The water in certain sections of the distribution system, upon hydrant flushing, was turbid and black with copious discharge of manganese.

Manganese can also be found in underground waters as a result of discharge of trade wastes high in manganese to infiltration ponds serving as waste treatment units. One example, in a location characterized by sandy soils with no underlying clay cutoff strata, resulted in a gradual buildup of manganese in the water of one well (of a well field of about eight units) to values as high as 2–3 ppm. Since both the well and the infiltration pond were owned and operated by the same industry, however, it is probable that the lack of complaint was due to the kettle being unable to call the pot black. Surely had the industrial waste polluted a municipal supply, vociferous objections would have been raised.

Unusual Iron Deposits

It sometimes happens that the presence of iron in samples of water can lead to very erroneous conclusions. A few examples will be cited:

1. Several years ago the author received a call from the water executive of a fairly large realty development. The water supply consisted of three or four drilled wells which up to that time had produced a satisfactory quality of water, virtually iron free. For reasons unknown, however, water samples began to contain 1–5 ppm of iron, and the consensus was that for some reason the character of the underground aquifer had completely changed. Since this condition would constitute a very grave abnormality, the wells were inspected and pumped at maximum capacity. Microscopic examinations made on the spot revealed the presence of *Leptothrix*, although the concentration was relatively low. The well casings were then backflushed and filled to static water level with a 100-ppm chlorine solution, allowed to stand a few hours, and then pumped to waste. Masses of *Leptothrix* up to fist size

were discharged, and the volume of this amounted to several pecks. The well was pumped to waste until all chlorine was dissipated and then allowed to remain idle for 3 days, after which another similar treatment was made. Thereafter there was no trace of iron. *Leptothrix* and its associated forms, *Crenothrix* and *Ulothrix,* can and do occur in wells, and these growths are able to extract sizable amounts of iron from well casings. Fortunately, however, such occasions are rare.

2. Several years ago the author received a water sample from another consulting engineer who requested an iron determination. A telephone conversation revealed the fact that a well driller had taken a contract on a guaranteed-quality basis and that a number of previous analyses by a number of different laboratories had produced a number of quite varying results. Such a background called for looking for abnormal, rather than normal, conditions. The water was taken from the well during test pumping and contained a sizable amount of sand. The first test, therefore, was not of the iron content of the water as such, but a microscopic examination of the sand grains. Under a stereoscopic microscope, a number of grains showed spots resembling markings on dice. These spots proved to be iron oxide, and the source of iron in the water sample was in reality not that dissolved or suspended in the water, but the spots on the sand itself. This was the author's first and last experience with iron-spotted sand, although a great many natural sands are completely covered with a thin coating of iron oxide, which is readily removed by an acid bath.

3. The author was once asked by an upstate New York municipality to make a corrosion survey and recommend methods of water treatment. There was no doubt whatever that iron in the central section of the city was rank, but contrary to normal expectations a decrease was found at the extremities of the system and even at dead ends. An examination of the watershed showed numerous springs discharging water heavily laden with iron, sufficient to cover ditch bottoms completely with iron sludge. The conclusion from this investigation was that an iron-laden spring with appreciable flow existed in the reservoir near the main intake and that water high in dissolved ferrous bicarbonate was being mixed with normal reservoir waters, with the result that precipitation took place after a period of an hour or so—when this water had reached the central portion of the city. An examination of cut sections of pipe from the distribution system showed corrosion of cast-iron pipe to be indeed slight. Tubercle formation was, therefore, the result of the plating-out of iron from solution, rather than such iron being derived from the metal of the pipe wall. This condition is rather an abnormality, although it has been observed occasionally. The author has seen a 4-in. section of cast-iron pipe so badly "tuberculated" that the carrying capacity was no more than would be obtained from a new pipe of 1-in. diameter. This is clearly an example of plating-out of iron, for the walls of the pipe after 80 years of service still have the coal-tar pitch intact, and there is no pitting. This is undoubtedly the result of discharge to the reservoir outlet line of mixed waters, a portion being from the zone of stagnation where iron exists in a soluble state, with another portion from the zone of transition or circulation, where iron is present only to a

slight degree but where oxygen is sufficient to effect precipitation in the pipeline during transit. Low velocity in pipelines is conducive to such a buildup, whereas a high velocity of 5 fps or more tends to prevent such deposits from ever getting a foothold.

Unusual Manganese Deposits

Of the two elements, iron and manganese, the latter is considerably more objectionable as well as being less understood. On the Hackensack River near Nyack, N.Y., manganese used to appear once or twice a year with no known provocations. Whereas this constituent is normally absent in the river water, it would occasionally rise to values as high as 5 ppm within a period of several hours. At such times, a sizable slug of finished water high in manganese would pass the filter plant and would occasion innumerable complaints from consumers on the distribution system. More or less by chance it was decided to record water temperatures and river stage daily. When several years of record had been made and were plotted, together with the occurrence of manganese, it was found that the water would contain extremely high concentrations—5 ppm or even more—in flood waters following the first rainfall after the brook water rose in July or August to a temperature of 76°F. This action is repetitive and constant. In fact, it is pointless to run the manganese determination except during the months of July and August, after water temperature has reached or exceeded approximately 76°F. Whether or not this action is biological, chemical, or biochemical is unknown. It can only be stated that the triggering action seems to be both thermal and hydraulic. It is possible that manganese enters the Hackensack River in solution and in manganous state, that it slowly precipitates and exists on and in the top layers of the mud bottom of the river as manganic hydrate, and that at a water temperature of about 76°F and over, low dissolved oxygen or biochemical activity results in its release from the mud and reabsorption in a manganous state by the flowing water. Its appearance with the first rainfall (after water temperature has risen to 76°F) is probably due to hydraulic scouring of the river bottom.

Abnormal Raw Waters

Whereas 98 of 100 well or surface waters fall into a well defined pattern, there always seem to be a few genuine surprises. Two of these came to the attention of the author during the past summer. One is a water from the Idlewild Airport section of Long Island, where three 12-in. wells were sunk to a depth of about 100 ft. The bottom 15 ft are equipped with a strainer, and static head in the wells approximates bay level. Drawdown at a pumping rate of several hundred gallons per minute is only a few feet. The total solids content of this water is about 25 per cent greater than that existing in the Atlantic Ocean off Long Island, the carbon dioxide content is 75–100 ppm, dissolved oxygen is completely absent, and the ferrous iron concentration approximates 50 ppm. There must be an answer for the presence of such ground water in this location, but no verifiable explanation is likely to be forthcoming in the near future.

Another completely abnormal water was encountered at the Christian Brothers Institute at Tarrytown, N.Y. This well is situated about fifteen miles south of Hudson, N.Y., and in close

proximity to the Hudson River. The geology at the surface is quite a variegated pattern. Water from a 300-ft rock hole had a pH of 9, a hardness of 4 ppm, and alkalinity of 300 ppm, and a colloidal suspension of several hundred parts per million. Spectrographic analysis showed this suspension to be silica and aluminum. Hydrogen sulfide was olfactorily present. This is the only well water ever analyzed in the author's laboratory from New York State with so high a pH, so high a sodium carbonate alkalinity, and so low a calcium carbonate alkalinity and hardness. The water also contained 100–200 bacteria per milliliter, of unidentified origin and nature but not of the coliform group. Needless to state, this water was totally unfit for practically any type of use, but after 2 months of pumping, colloidal silica has been eliminated and pH has been reduced from 9 to 7.6–8.0.

Conclusion

As has been said, perhaps 98 of 100 well and surface waters fall into a general category which is reasonably well understood, and iron and manganese are not too difficult to remove or control. It is also a fact in many locations, however, that, although not difficult to control, they are, and probably will always be, expensive to control.

Reference

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Removal of Iron and Manganese

E. J. Connelley Jr.

A paper presented on Sep. 24, 1957, at the Kentucky-Tennessee Section Meeting, Louisville, Ky., by E. J. Connelley Jr., Sales Engr., The Permutit Co., Div. of Pfaudler Permutit, Inc., Cincinnati, Ohio.

WATER is the major compound on the earth. It is the most important industrial raw material in use. Unfortunately, the waters which are available for use vary quite widely in their chemical composition and character. Certain problems found in surface supplies are not found in well supplies, and the reverse is true. Basically, in investigating a new water, in addition to its bacterial suitability for sanitary supplies, there is interest in the following constituents: hardness, alkalinity, turbidity or color, and iron and manganese content.

This article is concerned with iron and manganese, which affect, however, the other elements. Hardness comes from calcium and magnesium dissolved in the water. Not all areas are favored with a supply of low hardness content. Generally, for municipal practice as well as from the economic standpoint, waters containing high hardness are processed through municipal treatment plants to produce an effluent of 85–100 ppm.

Alkalinity, basically, is the total of all bicarbonate, carbonate, or hydroxide found in the water. Since the pH of the water is a direct function of the amount of alkalinity and carbon dioxide present, it assumes a very important position from the standpoint of treatment of water supplies.

Another item generally associated with surface supplies is turbidity. Although turbidity has generally been defined as those particles which are slightly colloidal in aspect, it has come to represent all dirt, sand, or colloidal particles found in water. A good example in Louisville is the turbid surface supply in the Ohio River. With other surface supplies, such as lakes, or streams, turbidity at times may be very low, or become high as experienced during seasonal changeovers, and may increase almost overnight.

Effects

The last two constituents—iron and manganese—have been some of the most troublesome of elements met in municipal and industrial supplies. Iron is fairly common, being found in one form or another in a large number of waters. Manganese, fortunately, is much rarer. Only a few iron-bearing waters contain manganese, and there are few waters containing manganese alone.

Iron and manganese contaminate everything they touch, producing ugly and insoluble rusty brown, yellow, gray, or black stains, blotches, and streaks. Iron usually produces yellowish-brown to reddish-brown stains, while manganese produces gray to black stains. But iron in contact with

certain substances (such as tannin) may also form gray to black stains.

Besides forming adherent deposits, iron and manganese can form insoluble suspended precipitates. Waters bearing these elements also generally favor the growth of iron and manganese bacteria, known as the *Crenothrix*. These *Crenothrix*, unfortunately, require only a small amount of air to grow, and since they thrive in the dark or light, they may be found in pneumatic tanks, pipelines, or elevated storage tanks. Since the bacteria after a period of time develop into a rather large growth, these growths can cut down available flow rates in or to a pipeline. In addition, if they break loose, the large masses will clog nozzles, lines, and valves. The bacteria as they decay impart a particularly bad taste and odor to the water, making it objectionable to drink or use for sanitary purposes.

Generally, water should be treated before use, reducing the total amounts of iron to service to less than 0.3 ppm and manganese to less than 0.1 ppm. With some industrial applications, it is required that the iron be reduced to 0.1 ppm and manganese to less than 0.05 ppm.

Forms

In iron-bearing waters, iron may occur in one or more of four forms:

1. In the nonacid ground waters, iron occurs generally as the ferrous bicarbonate. When freshly drawn, these waters are clear and colorless, but on standing in contact with air or upon agitation with air, they develop a whitish haze which then turns to a yellowish or reddish-brown haze. This color is caused by the fact that the ferrous bicarbonate oxidizes with air to form the highly colored insoluble ferric hydroxide. In a glass vessel, some of this deposit will cling to the sides, as well as settle to the bottom of the vessel. Depending on the pH and degree of aeration of the water, this oxidation may occur in less than 10 min, or at times may require several hours for completion.

2. The soluble ferrous sulfate iron is found in acid surface waters. This material when concentrated has a light green color, but with the great dilution present color is not noticeable. Also, in the acid surface waters, some of the suspended insoluble ferric hydroxide may be present. Although the acid ground waters are usually clear and free of suspended iron matter, iron may be present totally as ferrous sulfate or partially as ferrous bicarbonate. Often acid waters, both surface and ground, contain manganous sulfate, aluminum sulfate, and, except those containing some ferrous bicarbonate, various amounts of sulfuric acid. This condition is sometimes found in the upper regions of the Ohio River. Acid waters generally do not cloud and deposit iron on exposure to air, unless they are first neutralized or changed to the basic constituents (*1*).

3. Normally the colored waters such as found in the South result from the extraction of organic materials from decaying vegetation. High-color surface waters usually originate in swampy areas, while high-color well waters are usually found under overlying layers of peat. Many of the high-color waters contain iron in the organic or chelated form. When so held in the organic complex, this iron does not precipitate when aerated.

4. Red waters owe their appearance and name to suspended insoluble ferric hydroxide. These waters usually result from the action of a corrosive water containing dissolved oxygen on

the ferrous metal of mains, piping, or tanks. It may also be caused by ground water containing ferrous bicarbonate, which has received aeration by air lift pumps, pneumatic storage tanks, or open tanks.

In manganese-bearing waters, manganese with one exception may occur in the same form as iron. In the clear, colorless, alkaline ground waters, it occurs as the manganous bicarbonate, and in acid waters, it occurs as the manganous sulfate, usually in conjunction with ferrous sulfate, acid, and aluminum sulfate. In high-color waters, it occurs as a chelated manganese. The one exception is that it seldom occurs as suspended, insoluble manganic hydroxide, because it requires a higher pH to oxidize and precipitate it than is usually found in natural waters.

Methods of Removal

For the removal of iron and manganese from the water, equipment might be classified as: aeration and supplementary units, oxidation units, base exchange, aeration with coagulation or softening, catalyst use, and chlorine oxidation.

Aeration

Under the category of aeration are following types of units: coke tray aerator, degasifier, and pressure aerators. These units do not remove iron —although a small portion of the iron may adhere to the unit surfaces—but are used to introduce oxygen into the water. The air or oxygen causes the iron to go from the ferrous (Fe^{++}) to the more insoluble ferric (Fe^{+++}) state.

Coke tray aerator. This unit can be considered as less expensive than the degasifier and generally requires less maintenance for cleaning (Fig. 1). The iron film which coats the surface of the coke hastens the oxidation of the iron. The limitation on this unit from an engineering standpoint, however, is that it can be used only when the carbon dioxide in the raw water is less than 30–40 ppm. The unit is also available in a less efficient form utilizing wood slats only.

Degasifier. This unit utilizes a countercurrent principle. Raw water is introduced at the top, and air, forced in by a blower, is introduced at the bottom. The degasifier is more efficient in the removal of carbon dioxide than the coke aerator. The more CO_2 removed, the higher is the resultant pH, and the less the need for introduction of alkali. These units generally are built square or rectangular, with one side removable for cleaning. When used for CO_2 removal and iron oxidation, this type of unit is generally higher than a unit used with little or no iron and CO_2 removal. Performance of the unit will depend on the number of falls between trays or slats. With the aerator and degasifier units, a catch basin is required below the unit for transfer pump suction. Generally, these basins are sized on basis of the amount of iron and how quickly it will precipitate. A good rule is that this basin be of at least 30-min detention when the iron exceeds 10 ppm or more. In this way most of the precipitated iron will settle out and thus reduce the load on the filters. Generally, provision should be made for alkali feeding following aeration. Lime is preferred, due to its lower cost, but soda ash or caustic soda may be used to avoid increasing the hardness.

Pressure aeration. The pressure aeration unit is used on iron-bearing waters of little or no carbon dioxide

content, since the interest is only in oxidation of the iron and not increasing pH by CO_2 removal. In operation, a portion of the water is saturated with oxygen or air by means of a compressor and then recombined with the main flow. The unit may then be followed by a pressure-settling tank or roughing filter, followed by standard built of concrete, wood, or steel. As is understandable, because pressure filters are enclosed, the top surface cannot be inspected. It can operate to a higher head loss, however, than can the gravity type of filter. Either of the units can be operated by individual valves, a single multiport valve, or with an automatic gravity, valveless filter.

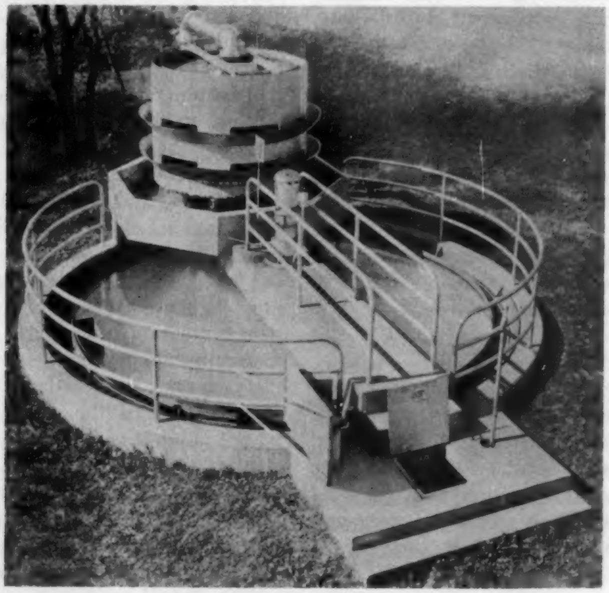


Fig. 1. Coke Tray Aerator

This unit is used for removing iron by aeration and the cold lime-softening process.

filtration. With pressure filters, this unit has the advantage of not requiring repumping, but it is generally found on industrial applications only.

The water, as pretreated by one of the three methods, is then passed to either gravity- or pressure-type filters. Pressure filters range in size from 30 in. to 12 ft in diameter. Gravity filters can be square, rectangular, or round, These units may normally be operated at rates up to 3 gpm/sq ft. Lower rates are recommended where the iron content is high.

Oxidation Unit

The oxidation type of unit, such as the oxidation filter, employs a manganese ion exchanger. In operation, this equipment is quite similar to a water

softener, except that the water coming in contact with the manganese ion exchanger, which causes the oxidation of the iron and the manganese, deposits the material in and on the filter beds. The unit is backwashed, regenerated with potassium permanganate, and put into service again. The general limitation on this unit is approximately 2 ppm iron. It does have the advantage of not requiring repumping.

Base Exchange

Another form of removal is by passing the water through an ion-exchange water softener, either of the hydrogen or sodium cycle. In this type of equipment, the iron is removed by base-exchange, together with the hardness. With regard to the sodium or hydrogen ion exchange of iron and manganese, since this occurs in solution or the ionic form, care must be taken that air does not enter the system. If air is present, it will cause oxidation of the iron and result in fouling of the ion-exchange bed. Since the operation is simple and can be made fully automatic, it should also be considered. In addition, repumping is not required.

Coagulation and Softening

Another form of treatment for iron removal is by passing the water through an aerator, and especially where chelated iron and manganese are present, through some type of coagulation or treatment unit. Although ferrous bicarbonate has appreciable solubility, ferric hydroxide has a solubility that is so low it is negligible, so in oxidizing ferrous bicarbonate to ferric hydroxide, the iron content of the water would be precipitated in an almost insoluble form. Oxidation is rapid and complete at pH values of 7.0 or higher. At a somewhat lower pH, the oxidation proceeds at a much lower rate. If the pH of the water is below 7.0, it is advisable to raise it to assure complete oxidation and removal of iron. Therefore, to maintain a pH of 7.0 or higher, it may be necessary to add some basic constituent, such as lime or soda ash. Actually, if the pH is raised to slightly above 8.0, the result is a very rapid oxidation of the ferrous bicarbonate in less than 15 min. Where amounts of manganese are also present, however, the generally used designs of rapid treatment can accomplish the same effect of the 4–6-hr settling basin in 60–70 min. Generally, these units will produce an effluent of less than 5 ppm turbidity. Therefore, although in plants set up for municipal supply the treatment is followed by filters—gravity or pressure—many industrial applications call for only the treatment unit, and the water flows directly to service.

Iron generally comes out relatively quickly at lower pH's. Efficient oxidation of manganese, however, requires that the pH of the water be lifted to 9–10.3. Actually, it is only when there is a pH of over 10.3 that it is possible to reduce the aerated manganese-bearing water to less than 0.2 ppm in 15 min. At a pH of 9.95, 10 ppm of manganese will be reduced to 0.6 ppm in 60 min. It must also be remembered, however, when hard water is treated and when the pH is raised above 8.3, precipitation of calcium carbonate will start. Therefore, with the use of the solids contact unit, a water containing iron, manganese, and hardness, can be lowered not only in iron and manganese but also in hardness, to give a better quality of water for service.

Catalyst Use

It is also possible to reduce manganese at lower pH values through the use of a catalyst. This catalyst is a precipitated manganic hydroxide, with which it is possible to reduce the manganese content to well within the range of use in a short period of time at pH's in a range of 8.5–9.0. Use of the cold-lime process would also cause the manganese present to form the manganic hydroxide at the higher pH's, so the effect of this catalyst would also be rapid precipitation and removal of the manganese.

Chlorine Oxidation

Another point that should be discussed is the oxidation of iron and manganese by chlorine. Here, generally, the same rules apply as noted previously, but with waters in a pH range of 4.9–5.1, the iron can be reduced to less than 0.1 ppm by the use of chlorine rather than aeration. With manganese the amount can be reduced somewhat at only slightly lower pH values than by aeration. Therefore, if the pH is to be raised, the chlorine should not be used unless as a post-treatment, following the aeration-type units in the settling basin or the cold lime-soda softener.

Summary

Iron and manganese are generally objectionable in a municipal supply when the iron exceeds 0.3 ppm and when the manganese exceeds 0.05–0.1 ppm.

Iron and manganese can be removed by aeration followed by filtration, oxidation filters, base-exchange units, aeration followed by lime-soda treatment on hard waters, or by oxidation with chlorine.

Generally, aeration and filtration are the cheapest and easiest to maintain, provided the pH of the water remains at 7.0–8.3 and only iron is present. If manganese is present, higher pH's are required and it is suggested that lime treatment be used with aeration.

Reference

1. HALE, F. E. Iron Removal Without Aeration—The Precipitation of Ferrous Carbonate in a Closed System. *Jour. AWWA*, **28**:1577 (Oct. 1936).

Successful Control of an Extensive Lawn-Sprinkling Load

Robert M. Grieve

A paper presented on Sep. 12, 1957, at the New York Section Meeting, Upper Saranac Lake, N.Y., by Robert M. Grieve, Supt. & Gen. Mgr., Citizens Water Supply Co. of Newtown, Great Neck, N.Y.

GREAT Neck, N.Y., is situated on a Long Island peninsula in the northwest corner of Nassau County, about 18 mi from the center of Manhattan. The area which is called Great Neck is made up of several incorporated villages and an unincorporated section of the town of North Hempstead. From a water consumption standpoint, the Great Neck community is strictly residential, and the majority of the homes are in the very high value bracket, with spacious lawns and extensive landscaping.

The major portion of the working population commutes daily to New York City to pursue various business and professional duties. It is generally said that Great Neck is one of the high-wealth communities of the United States. It is to this community that the Citizens' Water Supply Co. provides service.

Facilities

The water supply system is comprised of about 90 mi of mains, 700 fire hydrants, and fewer than 7,000 services, including underground lawn sprinkler systems, which are supplied through separate service pipes and meters. All services are metered. The source of supply is all from deep wells, varying in depth from 70 ft to more than 500 ft. Twelve well-pumping stations are strategically located within the 8-sq mi area served. The combined capacity of the twelve stations is about 14.5 mgd to serve the population of less than 28,000. As there is no industrial use to consider, it is easily determined that the well pumps *alone* are capable of delivering slightly more than 520 gpcd.

Booster stations and storage facilities, located in two areas of the distribution system, are equipped to deliver more than 500,000 gph at peak load, for nearly 4 hr. This 12-mgd pumpage rate of flow from storage, plus the well equipment capacity provides for the delivery of water at a rate equal to 26.5 mgd, or 940 gpcd.

It would seem, then, with wells able to furnish to 520 gpcd, plus an additional 420-gpcd rate available from storage for peak-use hours plus strategic locations of pumping and storage facilities (no difficult transmission problems), that the company's equipment would surely be considered adequate by almost any standard, especially when it is emphasized that on a yearly basis, water consumption equals about 112 gpcd, or slightly more than 3 mgd for the 1957 population of less than 28,000.

In other words, the situation is: an average demand of about 3 mgd; facilities to deliver almost five times the

average day requirements from wells; and storage capacity from which a rate equal to 12 mgd may be pumped for 4 hr of peak demand. It is possible, then, to deliver water at the rate of more than 8½ times the average-day demand. The questions might arise: What could require successful control? What is the problem?

The problem at one time was created by lawn sprinkling, with hoses and underground lawn sprinkler systems, the latter causing an excessive load which has recently been controlled so successfully.

Lawn Sprinkler Systems

Lawn sprinkler systems in Great Neck are supplied through separate service pipes and meters, ranging in size from 1 in. to 4 in. A survey conducted in late 1954 and in the spring of 1955 proved that the average lawn sprinkler system created a demand of over 70 gpm. There were 300 of these systems in use in 1954; at present, there are more than 400, and they are increasing.

A demand of 70 gpm by one sprinkler system is equal to the average rate required to supply a normal residential population of 700 or more—a whole small village.

The utility's equipment in July 1954 was equal to a 500-mgd demand (more than 12 mgd) plus an available 12-mgd peak rate for 4 hr from storage, or a total of 980 gpcd available for the peak-demand hours.

With all equipment in operation, the company failed on several occasions in the summer of 1954 satisfactorily to meet the unusual peaks, which were not of short duration. On a hot, dry Saturday near the end of July 1954, the utility was in difficulty before 11 AM. Even between 1 and 2 PM, water was being delivered at the rate of 860 gpcd to this truly residential community (there were higher flow rates on this day, of course).

On this peak day, the total day's pumpage was about 8.7 mil gal, or 350 gpcd. The peak-hour rate was about 2.5 times this peak-day and 8 times the average-day rate. Certain sprinkling restrictions were in effect at that time, such as permitting only even-numbered houses to sprinkle on even dates and only uneven-numbered houses to sprinkle on odd dates of the month.

It was evident that rigid control of underground lawn sprinkler systems was essential, because of their high average-demand rate of 70 gpm, too great a demand, surely, from the standpoint of simply watering a lawn. To satisfy this unreasonable demand was unfair to all of the company's patrons, as it was caused by less than 5 per cent of them, particularly when such demand and relatively low volume use was (and is) on a purely seasonable basis and so dependent upon whether or not it rains.

The economic factor involved is neither small nor insignificant, but it is a long and controversial subject, and not within the scope of this article. From an operating standpoint, however, it must be agreed that ten underground lawn sprinkler systems operating at 70 gpm each require pumpage equipment, and main capacity equal to a 1-mgd rate of demand and used only when there is not enough rainfall to do the job. A trace of rainfall has decreased pumpage from 10 mgd to about 3.5 mgd.

Early Regulations

As far back as 1950, the company realized that the high demand rate

caused by underground sprinkler systems was excessive and that such high flow rates were not essential for the purpose of lawn sprinkling. The company then decided to limit sprinkler system service pipes to 1-in. diameter, unless there prevailed lower pressure areas wherein a service pipe larger than 1 in. might be required. The company's tariff provided the right to determine service pipe size.

Unfortunately, this decision was not accepted favorably, and after a hearing before a controlling authority, the company was directed to provide service to lawn sprinkler systems through service pipes up to and including 2-in. diameter, as requested by the applicant. The decision, in part, did provide that a pressure regulator could be required in future installations on service pipes larger than 1 in.

Testimony at this hearing gave the information that the maximum volume of water required for proper lawn maintenance was 1 in. of water per week, either from rainfall or by sprinkling. Also, in part, the decision of the controlling authority gave permission to the company to control the operation of lawn sprinkler systems so that each of the 300 systems would be permitted to operate twice each week, placing ½ in. of water on the lawns at each of the two operations.

Needless to say, the decisions of this hearing offered a challenge. There was no precedent which could be followed, and the author, charged with the responsibility of reducing the meaning of these decisions to a painless, successful, working program, did quite a bit of planning and thinking. The daily life of the water utility is mostly challenge and decision, however, and a plan was worked out which officials hoped would provide the desired results of reducing peak pumpage rates, but without causing a serious decrease in the daily pumpage output.

Methods of Control

First, a survey of the existing lawn sprinkler systems had to be made. A two-man crew was carefully briefed and, during the late summer of 1954, was sent out to survey 300 lawn sprinkler systems, armed with: a stop watch, to time water flow through the sprinkler meter; a measuring wheel, to measure the lawn or the section of lawn irrigated by the system; and a 4 × 6-in. card to supply the foregoing data and other necessary information, such as service size and main pressure. As these survey cards were returned to the office, three computations were made on them: [1] the number of hundred square feet to be sprinkled and the amount of water required; [2] the average rate, in gallons per minute, delivered by the sprinkler system; and [3] the number of hours required to deliver 1 in. of water to each lawn.

On a 2 × 8-ft flow chart, made up from cross-sectional paper and used as a strip chart, days and hours appeared along the bottom, and gallons per minute in 10-gpm graduations, appeared vertically.

The rate of demand and the time required by each sprinkler system were taken from the survey cards and reduced to a curve on the strip chart within the actual hours and minutes to be assigned in the day or in the night. Time clock equipped systems were assigned operating hours that fell between 11 PM and 7 AM, and then only for the number of hours required to deliver ½-in. of water to the lawn per operational period, of which each system is assigned two for each 7 days.

TABLE 1

Water Demand at Great Neck, N.Y.

Item	Demand—*gpcd*	
	1954	1957
Average day	112	111*
High day	350	372
Peak hour	860	515

* Estimated.

A map of the distribution system was set up to receive small colored pins: white pins represented sprinkler systems which would operate each Monday and Thursday; pink, Tuesday and Friday; and blue indicated Wednesday and Sunday. No systems were assigned time on Saturday or between the hours of 5 PM and 8 PM on any day. Careful observation of the time and gallons per minute allocated on the strip chart, as well as further observation of the colored pins on the map, permitted an intelligent approach to the allocation of time to all sprinkler systems which followed the plan. Main sizes and elevations were given primary consideration.

A carefully worded and very explicit card was mailed to each lawn sprinkler system owner or operator. This permit, as it is unofficially known, clearly designates the time of day and the 2 days of the week during which his lawn sprinkler may be operated. The survey cards have become the permanent alphabetically filed records along with a record book, which is a duplicate of the survey cards.

Results

The results of this control method, inaugurated in the summer of 1955, of scheduling by exact timetable the operation of all underground sprinkler systems, proved to be highly successful. Data in Table 1 give conclusive evidence in proving the worth of the program.

Figures in Table 1 show that the high day in 1957 increased by 22 gpcd, which may be a reflection on the utility's failure to meet the peak demand in 1954.

In conclusion, the most significant fact is that the peak-hour rate has been successfully reduced from 860 to 515 gpcd. This shows a 40 per cent reduction of peak demand, while increasing production of the day by 6 per cent—considered by utility officials to be a most gratifying solution to a difficult problem.

Control of Water Use Through Fire Hydrants

John L. McBride

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by John L. McBride, Commercial Repr., East Bay Munic. Utility Dist., Oakland, Calif.

THE fire hydrant, a familiar sight in most communities for many years and the frequent butt of many jokes is known to the general public as a device to provide large quantities of water for fire fighting. Unfortunately, the omnipresent fire hydrant—especially in metropolitan areas—is frequently a source of difficulty to water utility operators.

Uncontrolled Use

Fire hydrants, with their convenient locations and 500-gpm flows are most attractive sources of water to building contractors. Many construction projects, today, involve the laying and compaction of large quantities of earth, the erection of structures which use considerable volumes of concrete, and many other operations which require large quantities of water. The ever cost-conscious construction superintendent must closely integrate the water transportation aspect of the job with related operations. This, of course, requires a convenient source of large flows of water for filling water truck tanks quickly.

The damage that can result to the distribution system or the hydrant itself when one is operated by an inexperienced person is well known to the trained water utility employee. Unfortunately, this knowledge is not shared by those who would like to draw water from a fire hydrant. The opening of a hydrant in certain locations on a distribution system can seriously disturb service to domestic customers by causing fluctuating pressures, water hammer, and dirty water. In addition, there is always customer reaction, especially in residential areas, to the fact that the hydrant water is being used without payment.

East Bay Plan

The East Bay Municipal Utility District was confronted with these problems to an increasing degree after World War II because of the tremendous construction activity in the area. In an effort to find a solution, the practices of other utilities were studied. It was noticed that—in some eastern cities particularly—the use of fire hydrants for other than fire protection purposes was forbidden. To completely deny contractors the use of hydrants seemed impractical. The district operates in the unincorporated areas of two counties and 13 cities and, because it has no police powers, would find it impossible to enforce a complete curb on hydrant use.

After trying several plans with varying degrees of success, the district adopted in 1951 the plan presently in effect for controlling hydrant use. In general, the plan operates as follows: A person wishing to draw water from

a hydrant must make application at a district business office 24 hr before service is desired. A deposit is collected to cover the value of the meter assembly required plus 2 months' estimated water bill. The application is phoned to the chief hydrant serviceman who operates from the commercial representative's office in the district's administration building.

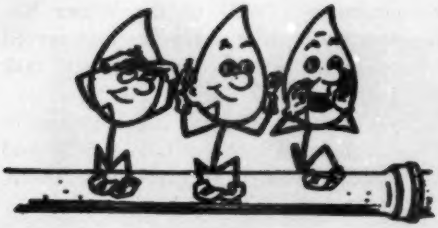
The chief hydrant serviceman meets the contractor's representative at the location where service is desired. A hydrant is then selected and a permit form filled out. After the serviceman presents the permit to the nearest fire department representative and secures his approval, the permit is returned to the applicant and the meter assembly connected to the hydrant. The applicant is carefully instructed in the use of the equipment and, because of the varying pressures in the distribution system which result from variations in terrain, particularly cautioned about the dangers of water hammer.

The meter assembly used by the district is composed of a 1.5- or 2-in. disc type meter to which a gate valve is attached on the inlet side. This assembly is connected to the hydrant with a 10-ft length of fire hose. By special arrangement, some firms are allowed to mount the meter directly on the tank trucks.

A $10 charge is made for the permit and installation and removal of the meter assembly. The water use charge is the same as for a domestic service, including minimums and meter service charge. The monthly minimums apply even though the period of use is less than a month.

Results

The district has received excellent cooperation from contractors in the observance of regulations and the cost of regulating the hydrant use pays for itself. According to figures of the district's functional accounting system, the revenue received exceeds by four times the cost of the chief hydrant serviceman position, his vehicle, and other equipment.



Percolation and Runoff

Big D was the name for it—in fact, **BIG D**—with everything bigger and better than ever before. Just how much bigger and how much better should be a little easier to specify next month than now on April Fools' Day, but to prove there's no fool like a bold fool, we do not hesitate to note now that there'll be no better measure of the biggerness of AWWA's 78th Annual Conference than the record registration of 3,333 that will descend on Dallas for the Big Doings on Apr. 20–25.

Leaving the Big Details for the confirmation of fact, we can turn to our own Big D's—the new Directors of AWWA and the new officers who will serve with them in guiding the Association in its 79th year of growth and accomplishment:

President—Lewis S. Finch, vice-president and chief engineer, Indianapolis Water Co., Indianapolis, Ind. Born in Anna, Ill., in 1897, he attended Purdue University, from which he was graduated in 1921, receiving the civil engineering degree in 1931. He is a registered professional engineer in Indiana. In the employ of the Milwaukee Sewerage Commission as senior engineer from 1923 to 1925, he joined the Indiana Board of Health in the latter year, serving as chief engineer until 1933, when he opened an office as consulting engineer. In 1942 he joined the Indianapolis Water Co. as principal assistant engineer, becoming chief engineer 2 years later, a director in 1948, and vice-president in 1950.

A corporate representative or active member of AWWA since 1926, he has been vice-chairman (1931), chairman (1932), and national director (1952–55) for the Indiana Section, which nominated him for the Fuller Award in 1949. His extensive committee activities have included vice-chairmanship of the Committee on Water Works Administration and chairmanship of the Committee on Water Main Extension Policy and the Committee on Public Use of Watershed Areas. He served as AWWA vice-president in 1957–58.

He has also been a member of the Ohio River Board of Engineers, the Great Lakes Board of Engineers, the Advisory Board of the Indiana Administrative Building Council, and the Indiana Advisory Health Council. At present he is vice-chairman of the Indiana Stream Pollution Control Board.

(*Continued on page 36 P&R*)

(Continued from page 35 P&R)

Other technical societies to which he belongs are ASCE (past president, Indiana Section), Indiana Engineering Society (past president), Indiana Engineering Council (past president), Central States Sewage Works Assn. (past president), FSIWA (director), Indianapolis Construction League (president), and NSPE.

Vice-President—Lauren W. Grayson, general manager and chief engineer, Public Service Dept., Glendale, Calif. Born in Boone, Iowa, in 1907, he joined the staff of the Riverside, Calif., Dept. of Public Utilities in 1926

V.P.—Grayson

Treas.—Orchard

and was appointed general manager in 1942. In 1951 he accepted the position of general manager and chief engineer with the Public Service Dept. of Glendale, Calif. He is a registered professional engineer in that state.

An AWWA member since 1933, he has served the California Section as vice-chairman (1948), chairman (1949), and national director (1952–54). In 1947 he was director of the former AWWA Plant Management and Operation Division, and was successively trustee (1948), vice-chairman (1955), and chairman (1956) of the Water Works Management Division, as well as vice-chairman (1948) and chairman (1949) of the Water Resources Division. He has also served on a number of committees and task groups.

Other professional organizations to which he belongs include ASCE and the California Municipal Utilities Assn. (past president).

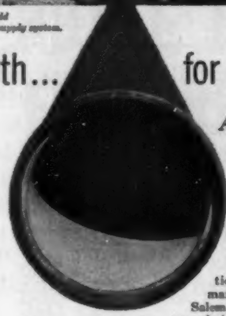
Treasurer—William J. Orchard, consultant, Wallace & Tiernan Inc., Belleville, N.J. Born in Boston, Mass., in 1888, he was graduated from Massachusetts Institute of Technology in 1911 with a degree in sanitary engineering. He served with the Massachusetts Board of Health and the Metropolitan Water Commission, and also held the post of assistant sanitary engineer with the New Jersey Health Dept. In 1915 he entered the employ of the Wallace & Tiernan organization. During World War I he originated and developed mobile water purification equipment for the US Army. He rose to the position of general manager of Wallace & Tiernan, retiring in 1954 but continuing as consultant to the company.

An Honorary Member of AWWA (joined in 1917), he received the Diven Medal in 1954 and the Jordan Achievement Award in 1956. A director for many years, he has served as chairman of the Convention Management Committee and as a member of the Executive Committee and the General Policy Committee. He was chairman of the Finance Committee from 1951 to 1957, when he was elected treasurer. Other organizations to which he belongs include WSWMA (past president), NEWWA, FSIWA, and APHA.

(Continued on page 38 P&R)

New Salem pipe line to augment present system will add approximately 80 MGD capacity to city water supply system.

a line of growth... for Oregon's capital city



American Concrete Cylinder Pipe is helping Salem, Oregon to grow

A simple but important fact is that no city, however great its potential, can grow beyond the capacity and dependability of its main water supply system.

Recognizing this fact, and envisioning a population in 30 years that will require three times the maximum capacity of present water transmission lines, Salem, the capital city of Oregon, is carrying out a program designed to meet future needs.

Under the direction of the City's Water Department Manager, John L. Geren, and the technical supervision of Consulting Engineers Clark and Groff of Salem, an 18-mile pipe line of 48" and 54" diameter American Concrete Cylinder Pipe is being installed by Lord Brothers, a general contracting firm of Portland, Oregon. This new line will triple the present capacity of the supply system.

The performance record of this type of reinforced concrete cylinder pipe has been so outstanding throughout the West that Salem can be confident that this water "growth line" will be giving efficient, economical service for many, many years to come.

Strength, permanence, sustained high carrying capacity, and trouble-free service are characteristics of American Concrete Cylinder Pipe which make it the right pipe for this forward looking city.

When planning your future water "growth lines," look to American's quality pipe line products, extensive production facilities and half century of experience.

Ask for complete information concerning the particular class of pipe that will meet your design requirements.

Los Angeles:
P.O. Box 3428, Terminal Annex • LOrain 4-2511
Hayward:
P.O. Box 630 • JEfferson [illegible]
Las Vegas:
P.O. Box 13 • CYpress [illegible]
Phoenix:
2025 South 7th St. • ALpine 2-1413
Portland:
518 N.E. Columbia Blvd. • BUtler 5-2531

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SECTION DIRECTORS

Indiana—John L. Ford Sr., vice-president and secretary, Ford Meter Box Co., Wabash, Ind. Born in Hartford City, Ind., in 1897, he received a B.S. in chemical engineering from Purdue University in 1920. In that year he joined Worthington Corp., remaining until 1924. Since then he has been with his present firm. He has represented the company in AWWA for many years and was vice-chairman (1937) and chairman (1938) of the Indiana Section, on whose nomination he received the Fuller Award in 1950.

Intermountain—W. Franklin Richards, director and superintendent, Ogden (Utah) Dept. of Water Works. Born in Salt Lake City, Utah, in 1907, he studied at the University of Southern California and Weber College at Ogden. He joined the US Bureau of Reclamation in 1934, where he served in various posts, including acting office engineer and architectural engineer. In 1948 he accepted his present position at Ogden. He has been an AWWA member since 1948.

Iowa—M. K. Tenny, general manager, Des Moines (Iowa) Water Works. Born in 1901, he was graduated from Iowa State College in 1922 with a B.S. in chemical technology. He served as assistant chemist with Hawkeye Portland Cement Co., Des Moines, in 1922–23, leaving the next year to become chemist and engineer for the Des Moines Water Works. In 1934 he was named assistant manager, and was appointed to his present position in 1955.

A Life Member of AWWA (joined in 1927), he has been vice-chairman (1951) and chairman (1952) of the Iowa Section. Other professional organizations to which he belongs include ACS and the Iowa Engineering Society. He has been a member of the Iowa Dept. of Health Advisory Committee on Fluoridation Projects.

Iowa—Tenny

Kansas—Hess

Indiana—Ford

Intermountain—Richards

Kansas—Robert H. Hess, director of water and sewage treatment, Wichita, Kan. Born in 1910, he holds an A.B. from Southwestern College (1933) and an M.S. from the University of Kansas (1936). He was an instructor at the latter in 1935, leaving the following year to become chief chemist with the Kansas Board of Health. In 1940 he joined the Wichita Water Dept. in the same capacity, becoming water supply superintendent in 1945. He was named to his present post in 1953. He is a registered engineer in Kansas.

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Mo.—Schworm

N.C.—Purser

An AWWA member since 1945, he received the Fuller Award in 1951 on nomination of the Kansas Section, which he served as vice-chairman in 1950 and chairman in 1951. He has been a member of the Task Group on Manganese Deposition in Pipelines. His other organizational affiliations include: NSPE, Kansas Engineering Society, American Electroplaters Society (director, Wichita Branch), FSIWA, and Kansas Assn. of Municipal Utilities.

Missouri—William B. Schworm, senior chemical engineer, St. Louis Water Div., Chesterfield, Mo. Born in 1903, he has been with the St. Louis Water Div. since 1925, serving as chemical engineer at Chain of Rocks Station until 1931, when he was transferred to Howard Bend Station. He has been in charge of plant operation at Howard Bend since 1938.

An AWWA member since 1942, he was chairman of the Missouri Section in 1953 and received the Fuller Award in 1955 on its nomination. He has been a member of the "Water Quality and Treatment" Revision Committee. He also belongs to the Missouri Public Health Assn., Society of American Bacteriologists, and Missouri Water & Sewage Conference.

North Carolina—John R. Purser Jr., president, Purser & London, Inc., sales engineers, Charlotte, N.C. Born in Charlotte in 1903, he received a B.S. from the University of North Carolina in 1925. He has been an AWWA member since 1939 and was trustee, vice-chairman, and chairman of the North Carolina Section, on whose nomination he received the Fuller Award in 1948. In 1946–47 he was editor of the North Carolina Section journal. He also belongs to the North Carolina Sewage & Industrial Wastes Assn. (past chairman), North Carolina Water Works Operators Assn. (honorary member), and North Carolina Society of Engineers.

Rocky Mountain—J. Orville Jones, general manager, Board of Water Works, Pueblo, Colo. Born in 1900 in Ridgefarm, Ill., he has been with the Pueblo water works since 1931. He joined AWWA in 1948 and has served the Rocky Mountain Section as trustee (1952–54), vice-chairman (1955), and chairman (1956). He is a member of the National Reclamation Assn.

Southeastern—Carl C. Lanford, engineer and superintendent, Commission of Public Works, Greer, S.C.

Rocky Mountain —Jones

Southeastern— Lanford

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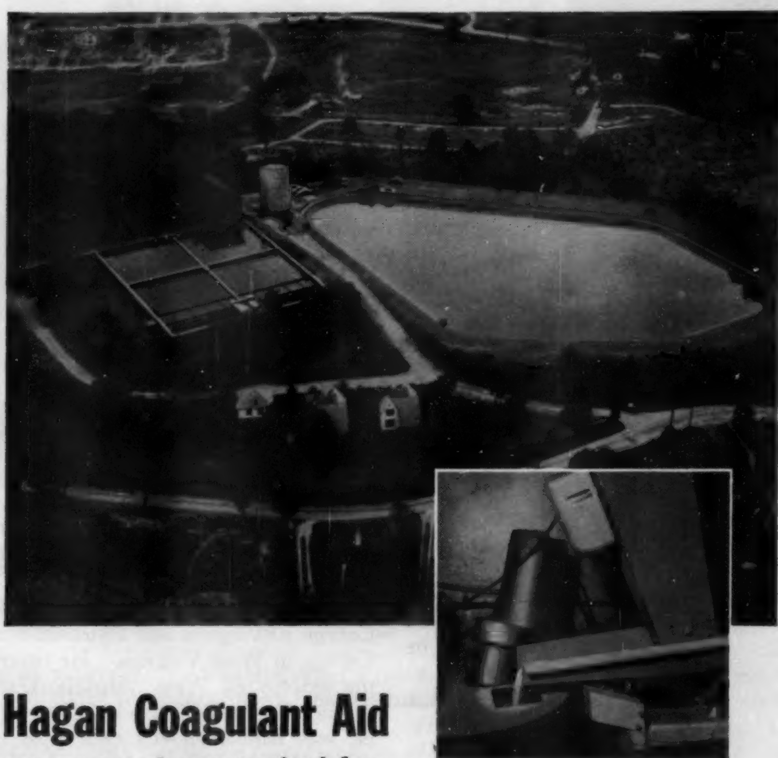

Hagan Coagulant Aids are easy to feed. They can be dry-fed or fed as a solution. The Wilkinsburg plant uses this dry feeder to put Coagulant Aid No. 18 into solution.

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Va.—Harman

W.Va.—Clark

Born in Woodruff, S.C., in 1904, he was graduated from Georgia Institute of Technology in 1926 with a B.S. in electrical engineering, joining the faculty in that year as a laboratory instructor. In 1928 he was employed as a junior engineer by Georgia Power Co., Atlanta. He has been engaged in municipal operations and engineering since 1933, and has held his present position for the last 16 years.

An AWWA member since 1941, he has served the Southeastern Section as trustee, vice-chairman, and chairman, and has been active in committee work. He is also a member of AIEE, FSIWA, South Carolina Water & Sewer Assn., American Public Power Assn., and South Carolina Municipal Assn. (founder and past chairman, Utilities Div.).

Virginia—William B. Harman, general manager, Newport News Water Works Commission. Born in 1892, he served as accountant for Newport News Light & Water Co. from 1920 to 1926, and as auditor for the Water Works Commission from then until 1937. In that year he was named assistant general manager, becoming general manager in 1952. He is also on the board of trustees of the City of Newport News Employees Retirement Fund.

An AWWA member since 1934, he has been trustee (1943–44), vice-chairman (1945), and chairman (1946) of the Virginia Section, and is a recipient of the Old Dominion Citation (1954) and the Fuller Award (1956). His committee activities include work on the "Manual of Water Works Accounting" Review and Recommendation Committee, as well as the Water and Sewerage Industry Advisory Committee to the National Production Authority. He also belongs to the American Public Works Assn., Appomattox River Development Committee, and James River Basin Assn.

West Virginia—Dennis H. Clark, superintendent, West Virginia Water Service Co., Bluefield, W.Va. Born in 1905, he attended Hampden-Sydney College in Virginia and Bluefield State College in West Virginia. He entered the employ of West Virginia Water Service Co. in 1929 as clerk. In 1931 he was named superintendent of the firm's Welch, W.Va., plant, a position he held until 1956. In that year he took on his present assignment. An AWWA member since 1939, he was chairman of the West Virginia Section in 1948 and held the chairmanship of the Section's Safety Committee in 1957–58.

Wisconsin—O. J. Muegge, state sanitary engineer, State Board of Health, Madison, Wis. Born in 1900, he holds a B.S. in civil engineering from the University of Wisconsin (1923) and an M.S. from Harvard (1937). He has been with the Wisconsin Board of Health since 1923, and is a registered professional engineer in that state.

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Wis.—Muegge

Mfrer.—Frank

A Life Member of AWWA (joined in 1925), he served the Wisconsin Section as trustee (1942), vice-chairman (1943), and chairman (1944), and received the Fuller Award in 1951 on its nomination. He is a member of the Task Group on Fluoridation Materials and Methods.

Among other professional organizations to which he belongs are: APHA, CSSE, Conference of Wisconsin Sewerage Works Operators, FSIWA (director), Great Lakes–Upper Mississippi River Board of State Sanitary Engineers, Midwest Benthological Society, Middle States Public Health Assn., NSPE, and Wisconsin Assn. for Public Health.

Manufacturer—J. A. Frank, vice-president and general manager, National Water Main Cleaning Co., New York. Born in 1909, he was graduated from Stevens Institute of Technology in 1933. He has been with National Water Main Cleaning Co. since 1936, serving successively as engineer, chief engineer, field manager, and vice-president and general manager (since 1946). He is a licensed professional engineer in New Jersey.

An AWWA member since 1940, his extensive activities have included service on a number of AWWA sectional and national committees, and he has represented AWWA on the EJC Committee on International Relations. Among his other professional affiliations are: FSIWA, NEWWA, Inter-American Assn. of Sanitary Engineers (past president), Pennsylvania Water Works Operators Assn., National Assn. of Corrosion Engineers, and WSWMA (past president and member of board of governors).

The weather works, about which even our most reserved comment seemed rather overimaginative 10 years ago, may now be upon us a lot faster than research and development during that 10 years have indicated. And the magic words that may make that possible are: "Weather is a weapon.". When, in his final report to President Eisenhower, Capt. Howard T. Orville, head of the Advisory Committee on Weather Control, said "If an unfriendly nation gets into a position to control the large-scale weather patterns before we can, the results could even be more disastrous than nuclear warfare," he really set loose the Red bogeyman who scares up funds. And going along with him were: Dr. Bernard Vonnegut, pioneer researcher in the weather control field, who visualized a Russian cloud over us that would prevent sunlight from ever shining through; Dr. Edward Teller, A- and H-bomb expert, who has pooh-poohed science's concern over the dangers of radioactive fallout but is fretful at the thought of Russia's ability to influence our rainfall; and Professor Henry G. Houghton, MIT meteorologist, who shudders at the consequences of a prior Russian discovery of weather control whereby they could modify our climate and "seriously weaken our economy

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and our ability to resist." Somehow or other, in the light of all that all of our experts have said in the past about our inability to do anything significant about controlling the weather before a great deal more basic research is carried out, we begin to suspect that this sudden discovery of the strategic value of weather has been contrived. And what a horrible contrivance, too—to make every thunderstorm a message from Khrushchev, every flood and drought a Russian plot, every hurricane a Soviet sweep. No, with Joseph Kaplan, chairman of the US National Committee for the International Geophysical Year, we have a feeling that these predictions of peril are extravagant. And if he is willing to feel "less critical about the many extravagant claims that have been made if they generate increased scientific research into the effects solar physics will have on the science of meteorology," we are not, because fear, we feel, is a poor substitute for reason in the establishment of our defense or our research appropriations.

Weather works designed to improve our own weather rather than to disimprove an enemy's could, of course, work greatly to our advantage. Merely by leveling out rainfall they could reduce storage requirements and peak loads, and, thereby, make a tremendous difference in the job of water utilities. But weather workers have much bigger ideas than that. A "clean" hydrogen bomb, they say, may someday trim mountains, melt ice caps, and thus change world wind patterns—may even drive the smog away from Los Angeles. Hurricane fury may be blunted, even diverted from land, by enormous heat updrafts from fuel oil poured on the ocean surface and lighted. Chemicals, such as hexadecanol, may be spread on water surfaces not only to slow down evaporation but to reduce rainfall on adjacent land areas. And coal dust or a similar dark coating spread widely on snow-covered tundras may be used to absorb solar energy, thawing the land and making it tillable.

Meanwhile, from weather workers a little closer to the present come reports of success on the more modest scale supported by past research and present ingenuity. Thus, from the US Forestry Service in California comes news that the number of lightning-set fires in the state's national forests was greatly reduced during the summer of 1957 by silver iodide seeding of the clouds on 27 days over a 3-month period. From Australia's Commonwealth Scientific & Industrial Research Organization comes word of a single cloud-seeding expedition that triggered a cloudburst, raising the level of the Leichardt River 17 ft in 2 hr and completely filling a dry power dam owned by the mining company that had contracted for the seeding. From Australia, too, came a report that the government has adopted a Canadian technique of spraying water from plane tanks to control forest fires, thus making rain rather than coaxing it from the clouds. From the US Northeast complete success is reported in creating snowstorms on ski slopes by machines which depend not on the clouds, but on water, temperature, and a spraying device to spread snow where it is needed when it is needed. And finally, from various water utilities in the US, have come reports of definite increases in precipitation by cloud seeding.

Whenever weather works come, water works can profit from them—unless, of course, they come classified and clouded for the kill!

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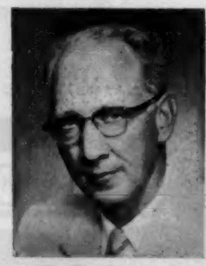

F. E. Dolson

H. O. Hartung

St. Louis County Water Co. announces the election of two new vice-presidents. Frank E. Dolson, superintendent of distribution, is vice-president and manager of distribution, and Herbert O. Hartung, superintendent of production, is vice-president and manager of production. Both men have been with the company since 1931.

Hot-garbage disposal is a problem that is getting increasing attention these days, not only for its importance in preserving the safety of water supplies but because it is one of the keys to reducing the cost of producing atomic energy. Right now the permanent leakproof containers with heavy shielding required for safe burial of radioactive wastes represent a significant expense, but it may soon be considerably reduced. Actually three new methods have been proposed:

First, Dr. Warren J. Kaufman of the University of California has suggested the possibility of injecting the wastes into deep fossil formations far below the level of useful ground water, with the thought that these formations will provide more permanent containers than man can construct. Then, along the same line, Dr. Curtis L. Newcombe of the US Naval Radiological Defense Lab. at San Francisco has pointed to the "fossil waters" at the bottom of meromictic lakes—that is, lakes which do not have a complete surface-to-bottom circulation—as both stable and permanent repositories for such wastes. And finally, tackling the problem from another angle, General Electric Co. scientists at the Hanford atomic plant have developed a milky-white jelly of sodium silicate and a solution containing aluminum into globules of which they inject radioactive wastes, whose heat then turns the jelly into a hard, glasslike material, adequate to imprison the wastes until they have harmlessly decayed.

None of these methods has been fully investigated as yet, nor, as far as we know, has anyone looked into the matter of rocketing these wastes into outer space, but it's the very existence of the problem that gives us the creeps. Remember the "good old days" of water power, when the garbage was cool and tasty and "E" equaled effort rather than mc^2? On second thought, it begins to sound as if it may soon be more of a problem to be an old fossil, so we suppose we'll just have to dig this deep garbage and all that goes with it.

A Ph.D. degree in sanitary engineering will now be obtainable at the University of North Carolina's School of Public Health. Major fields include water supply and treatment, waste treatment and disposal, environmental sanitation, and atmospheric pollution control, with minors in chemistry or the biological sciences. Graduate teaching and research assistantships, research associateships, and fellowships are available to qualified students. Information may be obtained from: Dept. of Sanitary Engineering, School of Public Health, Univ. of North Carolina, Box 899, Chapel Hill, N.C.

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Dowsing, long a favorite subject of P&R, lost a lot of its lure last July with the death of the man we liked to call the Father Diviner—that is Kenneth Roberts, who, though not a dowser himself, was certainly dowsing's doughtiest disciple and most disputatious defender. Famous first for historical and, only lately, hysterical fiction, Roberts had the last of the latter series of his 26 books in type at the time of his death. Like *Henry Gross and His Dowsing Rod* and *The Seventh Sense* which preceded it, *Water Unlimited* * is a collection of angry nonscience that will prove to the complete satisfaction of those who believe in dowsing that dowsing works and that skeptics—and particularly geologists—are the worst of Philistines.

All is not lost, of course, for as indicated in a recent survey reported by the American Geological Institute, there are approximately 25,000 dowsers in the United States alone. And, although they are reported to average over 65 years of age and to be most commonly found in sparsely settled rural areas, we have an idea that news of their feats will continue to beleaguer us for as long as there is percolation and runoff, much less "Percolation and Runoff."

That it was thus at least as long as a hundred years ago is indicated by these comments of the *Scientific American* of April 1857:

From the number of communications which we have received on the divining rod, we cannot question the *honest* belief of a number of our readers in its virtues. There are many phenomena in nature which are yet sealed up to us, and the divining rod may be one of these; still, we must say that we are skeptics in the powers or virtues which are attributed to it. We believe that any man of a reflecting and observing mind can guess where water may be obtained by boring, without a divining rod, as well as another person with one. Our opinion may be wrong, but we cannot come to any other conclusion by reasoning on the subject from scientific data. If, however, we are at any period of time after this convinced by ocular demonstration that there is scientific virtue in the divining rod, we will frankly make the change of our views known.

* Doubleday & Co., Inc., Garden City, N.Y. (1957) $3.95.

That it remains thus may be indicated by such up-to-date applications as the "new scientific Water-Probe," which is being offered at the ridiculously low price of 69 cents at Spencer Gifts of Atlantic City, N.J., to:

Locate hidden water springs, gas, or even sewer lines without digging. . . . Sensitive to depth of 30 ft. Simple to use. Finds underground streams as efficiently over concrete as bare ground. Works on principle of dissimilar metals and elements attracting. Save hours of unnecessary digging.

And that it is likely to continue thus into the outer reaches of space and time must be suggested by the fact that the problem of finding water is already a principal concern in the discussion of exploring other planets. Having heard of some of the fantastically expensive scientific schemes for obtaining water in heavens above, we could have counted on Kenneth to write *Cheaper by the Dowsing!*

Edward S. Hopkins, sanitary engineering consultant, has moved his office to the Professional Bldg., 330 N. Charles St., Baltimore 1, Md.

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Robert H. Harmeson is the new head of the Peoria Research Lab. of the Illinois State Water Survey. He succeeds Max Suter, who has been named principal engineer on special assignment to study ground water conditions in northeastern Illinois.

RFD in Iowa has come to mean "rough for dogs," there being a state law authorizing a postman to kill any dog that bites or attempts to bite him. If the postman happens to be soft hearted, of course, the initials will revert to their meaning in other states, based on Postmaster General Summerfield's recent action on behalf of last year's 6,000 hard-bitten postmen—that is, "rough for dogowners," who will be required to go to the post office to collect their own mail if they have dogs that are unkind to postmen. Such governmental anticaninity can be a help to water utility personnel, too, if it is successful in training dogowners to train their dogs. As far as method is concerned, however, neither the "shoot on bite" nor the "come and get it" technique is likely to build good public relations. "Run from danger" is probably the best all-around RFD for any water works man!

Water conditioners, those gadgets whose principles have been clothed in such abstruse semasiology that we haven't even dared grapple with them, have finally come out of the woods. Now, at last, a water conditioner whose principles and purposes we can fully understand has been announced by Elgin Softener Corp. of Elgin, Ill. Actually the announcement has been rather limited in distribution as the device is both unpatented and unpending, but, in the hope of drumming up some advertising for the JOURNAL, we don't hesitate to quote the preliminary brochure for the "New! Amazing!" ELWAS Water Conditioner in full:

· Chrome Plated · Heavy Cast Steel · No Secret Compounds · Water Flows Either Way · No Special Tools Required · One Price for All Sizes · $3.95 Complete

We make no specific claims for the ELWAS Conditioner except those we can back up. While it won't particularly change the quality of your water, its rugged construction and chrome finish undoubtedly make it one of the most unusual fittings of its kind. No special tools required other than those normally carried in the well equipped plumbing shop. Can be installed forward or backward with equal results. Finish and styling make it an asset to ordinarily drab piping systems. *See your dealer today.*

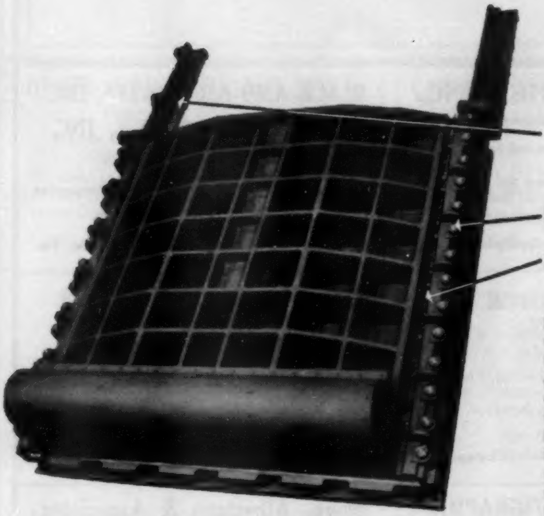
ELWAS never like this!

A McIlroy network analyzer is being donated by Standard Electric Time Co., Springfield, Mass., to Western New England College, for use in the science building to be constructed on the college's new campus at Springfield. The gift will serve several purposes; students will use it in their course on analog computers, and it will be available to municipal or commercial companies on a rental basis, as well as to Standard itself. Western will become the fourth college to have the device, the others being Cornell, Tufts, and State College of Washington.

David D. Ackerman has been elected president and a director of Ludlow Valve Mfg. Co., Troy, N.Y., and its Canadian subsidiary. Formerly vice-president and general manager, he succeeds Earl W. Pughe, retired.

(*Continued on page 106 P&R*)

2,300 pounds of Everdur used in new 8-ton cast-iron sluice gate



1 ¾" x 3" Everdur facing strips for gate leaf and frame.

2 1½" Everdur bolts and nuts.

3 Everdur adjusting bolts for cast-bronze wedges.

More than a ton of Everdur was used for facing strips and fastenings in this 8' x 8' sluice gate leaf and frame assembly designed and furnished by the Coldwell-Wilcox Division of Krajewski-Pesant Mfg. Corp., New York City. Consulting engineers, Gannett Fleming Corddry & Carpenter, Inc., Harrisburg, Pa.

This direct-pressure type sluice gate is one of two recently installed by Empresa de Energia Electrica at the Quebradona Dam in Columbia, South America, to regulate the flow of potable water to the city of Medellin.

The 100-foot head of water behind the dam exerts 450,000 pounds pressure on each 8 x 8-foot gate. Everdur* (copper-silicon alloy) was selected to seal against this load because of its high strength and corrosion resistance—plus ready workability and weldability. Sewage treatment and water works equipment of Everdur has been in service without replacement for a quarter century and longer.

Write for Publication E-11, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment"—or for technical help in selecting the correct material for your job. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont.

*Reg. U.S. Pat. Off. 57128

EVERDUR Anaconda's Family of Copper-Silicon Alloys
MADE BY THE AMERICAN BRASS COMPANY

STRONG • WORKABLE • WELDABLE • CORROSION-RESISTANT

Professional Services

Professional Services

Professional Services

Professional Services

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL ANALYSIS

The Determination of Ammonia and Total Ionic Inorganic Nitrogen in Sea Water. J. P. Riley & P. Sinhasen. J. Marine Biol. Assoc. (London), **36**:161 ('57). In sepn. of ammonia from sea water by vacuum distn., special app. is required and process is time-consuming. It has now been found that microdiffusion using Cavett flask is as satisfactory, diffusion being about 75% complete after 24 hr at 70°C. Recovered ammonia is then detd. by modification of phenate-hypochlorite method. Nitrate and nitrite in sea water can be detd. by reduction to ammonia with Raney nickel in presence of EDTA; ammonia is then separated by microdiffusion and detd. colorimetrically. No interference was encountered from variety of org. nitrogen compds.—*WPA*

New Indicator for Complexometric Titration of Calcium in Presence of Magnesium. G. P. Hildebrand & C. N. Reilley. Anal. Chem., **29**:258 ('57). New indicator, Calcon CI 202, has been developed for complexometric detn. of calcium in presence of magnesium. Titration is carried out at pH 12.3 in diethylamine buffer, and at endpoint there is sharp change from pink to pure blue. Indicator forms a 1:1 complex with calcium. —*WPA*

Calcein as an Indicator for the Titration of Calcium with Ethylenediaminetetraacetate. B. M. Tucker. Analyst (UK), **82**: 284 ('57). Calcein (fluorescein complexone) has been developed as indicator for calcium in titrations with disodium EDTA. Color change on titrating calcium with EDTA above pH 12 is from bright green fluorescence to pinkish orange with some residual fluorescence. Endpoint can be improved by addn. of thymolphthalein. Suitable indicator mixt. consists of 0.2 g calcein, 0.12 g thymolphthalein, and 20 g potassium chloride ground together to fine powder. About 10 mg of this powder are required for titration vol. of 50 ml. Procedure for detn. of calcium in presence of magnesium is given.—*WPA*

New Complexone for Titration of Calcium in the Presence of Magnesium. R. W. Schmid & C. N. Reilley. Anal. Chem., **29**: 264 ('57). Complexometric detn. of both calcium and magnesium has always involved pptn. of 1 of these ions. This step can be eliminated by titration with complexone, ethylene glycol bis-(β-aminoethyl ether)-N,N'—tetraacetic acid, which complexes calcium selectively in presence of magnesium. Sum of calcium and magnesium is detd. by titration with (ethylenedinitroli)-tetraacetic acid, and magnesium is detd. from difference between 2 results. Endpoints are detected potentiometrically, using mercury indicator electrode.—*WPA*

The Determination of Organic Carbon in Marine Muds. S. K. Wakeel & J. P. Riley. J. Cons. Permanent Intern. Exploration Mer, **22**:180 ('57). Method has been developed for detn. of org. carbon in marine muds, based on oxidation with chromic acid and titrimetric detn. of oxidant consumed. Empirical correction factor has been evaluated to correlate carbon content found with that obtained by combustion. When about 1% of carbon is present, coefficient of variation of about 7% is found. Method can also be used, with slight modification, for approximate anal. of plankton.—*WPA*

Determination of the Carbon of the Organic Material in Natural Waters by the Method of Dry Combustion. L. P. Krylova. Gidrokhim. Materialy (USSR), **26**: 237 ('57). This is micromethod. 3-25 mg H_2O is mixed with K_2SO_4 + NaCl or KCl and evapd. to dryness with subsequent com-

(*Continued on page 64 P&R*)

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bustion in stream of O_2. C can be detd. in as little as 10 γ of org. material with error of ±3%. The developed CO_2 is caught in 0.02*N* $Ba(OH)_2$. Some $K_2Cr_2O_7$ can be added to K_2SO_4, in order to be certain that combustion goes to completion; as rule, this is not necessary. Method was worked out with alanine and asparagine as org. material, then applied to H_2O from Pacific Ocean and Black Sea.—*CA*

Chemical and Physicochemical Methods in the Practice of Waterworks. S. JANKOVIC. Tehnika (Buenos Aires), **10**:561 ('55). Recent methods for detg. Cl and Fe contents, hardness, pH, degree of turbidity, and cond. of city water are discussed.—*CA*

A New Method for the Microdetermination of the Cupric Ion (in Water) by the Use of an Enzyme. I. YAMAZAKI & K. FUJINAGA. J. Chem. Soc. Japan, Pure Chem. Sect. (Jap.), **77**(8) : 1213 ('56). It was found that rate of oxidation of reductone (I) with peroxidase (II) increases in presence of Cu ($>10^{-8}M$) at pH 7.3 (0.0025*M* phosphate buffer). Amt. of I ($\cong 10^{-4}M$) oxidized during given time of reaction is proportional to concn. of Cu ($<10 \times 10^{-8}M$). Similar effect is observed with Mn ($>10^{-6}M$) and Co ($>10^{-6}M$). Sample soln. (0.5 ml) is made up to 4 ml with II soln. ($10^{-7}M$, its concn. is detd. from its absorption at 403 mμ), buffer (0.5 ml) and I soln. ($4 \times 10^{-4}M$, made from glucose and NaOH), and set aside at 25°. Reaction is stopped by addn. of 3*N* H_2SO_4 (1 ml) and amt. of unchanged I is detd. iodometrically. This method can be satisfactorily applied to detn. of Cu in natural and purified water.—*PHEA*

Titration of Cyanides With Bivalent Nickel Salts to Catechol Violet. J. VRESTAL & J. HAVIR. J. Chem. Listy (Czech.), **50**:1321 ('56). Complexometric method for detn. of cyanides using catechol violet as indicator is described. Buffer soln. for this reaction is made up by adding 80 g ammonium nitrate and 300 ml of 35% aq. ammonia to 1 liter water. Cyanide soln. is dild. to 100 ml, then 5 ml of buffer soln. and 5 drops of 0.1% aq. soln. of catechol violet are added. This is then titrated against 0.03*M* nickel nitrate soln. until violet color

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changes to blue. Avg. error using this method is ±0.1%. Chlorides, carbonates, and phosphates do not interfere.—*WPA*

Volumetric Determination of Cyanide and Nickel With Resacetophenon Oxime as an Indicator. K. S. Bhatki. Analyst (UK), 82:24 ('57). Using resacetophenone oxime as internal indicator, soln. of cyanide can be standardized against standard nickel soln. prepared from extra-pure nickel ammonium sulfate, thus avoiding use of more expensive reagent such as silver nitrate. Method can also be adapted for indirect detn. of nickel, but interference is caused by copper, cobalt, zinc, and certain other metals that generally occur with nickel and which can form complex cyanides.—*WPA*

The Amperometric Titration of Microgram and Submicrogram Quantities of Fluoride. J. K. Johannesson. Chem. & Ind., p. 480 ('57). Details are given of method for detn. of small quants. of fluoride in water by amperometric titration with thorium nitrate in dil. perchloric acid, using rotating aluminium electrode and stationary platinum anode. Construction of aluminium electrode is described.—*WPA*

Determination of Small Amounts of Fluorine in Aqueous Solutions. M. G. Lubyanskaya. Fact. Lab. (Moscow), 22:921 ('56). Method for detg. quants. of 0.01–0.1 mg fluorine in water is described. Sample is mixed with sodium alizarinsulfonate soln. in flat bottomed cylinder and dil. acid or alkali are added until color matches that of similarly treated twice distilled water. Dil. hydrochloric acid is then added and soln. is titrated with zirconium nitrate soln. to permanent pink color. Calibration curve is obtained by titrating various dilns. of standard sodium fluoride soln. Allowance must be made for effect of temp. and sulfate ions on slope of this curve.—*WPA*

Estimation of Fluorine in Waters Containing Excessive Amounts of Interfering Ions. P. Venkateswarlu & D. Narava-

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NARAO. Indian J. Med. Research (Ind.), **45**:273 ('57). Adsorption of F ions on MgO in boiling solns. gave method for estn. of traces of F in waters contg. interfering ions, that avoided usual evapn. of large vols. Of important interfering ions only PO_4 was found in waters tested. 200 ml water, just alk. to phenolphthalein, was brought to boil, 0.2 g of light MgO added, and boiled for 10 min. After cooling and centrifuging, MgO and adsorbed F was submitted to Willard-Winter distn. Distillate was titrated for F ion by Smith-Gardner technique. Values obtained were in good agreement with those from conventional evapn. method. —*CA*

Polarographic Testing of Drinking and Usable Water. I. Determination of Hardness and Alkali-Metal Content. J. PROSZT & K. GYORBIRO. Chem. Anal. (Warsaw), **1**:2-3:21 ('56). Polarographic methods, with mercury-jet electrodes, for direct detn. of K, Na, Ca, and Mg are described. Magnesium is detd. with 0.4 to 0.8*M* tetramethylammonium chloride at pH 5.4 to 6.8 as base electrolyte. Diffusion current is proportional to concn. of Mg in range 5×10^{-4} to $3 \times 10^{-3}M$. Calcium is detd. similarly at concn. of 2×10^{-4} to $5 \times 10^{-3}M$ in pH range 4.8 to 9.4. Potassium and sodium are detd. as their sum at any pH value above 4.5. Half-wave potentials are −2.15 V for K, −2.16 V for Na, −2.36 V for Ca, and −2.53 V for Mg. Results with pipe-water, river, well and mineral waters were in good agreement with those obtained by compleximetric methods for Ca and Mg and ion-exchange method for Na and K.—*PHEA*

Conductimetric Titrations in Chelotometry. II. Determination of Total Hardness of Water. F. VYDRA & M. KARLIK. Chem. Listy (Czech.), **50**:11:1754 ('56). By using conductimetric indication of equivalence point, total hardness of water may be detd. compleximetrically. Procedure: dil. sample (containing $\not>$ 4 mg of Ca plus Mg) to 200 ml, add 0.05*M* $Na_2B_4O_7$ (5 ml), KCN soln. (10%) (0.3 ml) and triethanolamine (10%) (0.3 ml), and titrate with 0.02*M* EDTA, measuring cond. after each addn. of titrant (0.2 to 1 ml). Copper, Fe and Al are masked with KCN and triethanolamine; Mn must be absent. Detn. can be carried out even when Eriochrome black T cannot be used as indicator—e.g., in presence of ClO.—*PHEA*

Conductometric Method for Determination of Water Hardness With Complexon III. G. B. PASOVSKAVA. Zhur. Anal. Khim., **12**:523 ('57). Hardness of turbid and colored waters was detd. by conductometric titration with 0.1*N* complexon III soln. Titer of latter was established by titration of 0.01*N* soln. of $CaCl_2$ and $MgSO_4$ taken in 3:1 ratio by vol. Titrations are done in presence of buffer consisting of 1*N* NH_4Cl and NH_4OH taken in 1:5 ratio by vol.—*CA*

Determination of the Calcium and Magnesium Hardness of Water. T. B. STYUNKEL & E. M. YAKIMETS. Elek. Stantsii (USSR), **28**:8:10 ('57). Ca and Mg are titrated with soln. of Trilon B in same sample with Chrome Dark-Blue as indicator. First Ca is titrated till color changes, then NH_4Cl is added and, after 2 min, titration is continued; this gives value for Mg.—*CA*

Rapid Semimicromethod for the Determination of Water Hardness. H. A. CAMIOU. Rev. Asoc. Estud. Quim. (Urug.), **5**:4:59 ('56). Schwartzenbach complexometric method is adapted for rapid detn. of water hardness. Concn. of chelating agent (di-Na salt of EDTA) is so adjusted that hardness in French degrees is given directly by number of drops of reagent required to reach endpoint in sample of water buffered to pH 10 with NH_4OH-NH_4Cl soln., and contg. Eriochrome Black T as indicator for Mg ion.—*CA*

Determination of Total Hardness in Carbon Dioxide–Containing Waters. S. D'ARCA. Nuovi Ann. Igiene e Microbiol. (It.), **8**:28 ('57). Versenate method of detg. water hardness was also satisfactory for CO_2-contg. waters (13 artificial samples contg. 600 cc. CO_2/l, hardness 20–140 French degrees; and 5 natural samples with 430–1100 cc. CO_2/l and 31.7–126 French degrees hardness).—*CA*

Apparatus for the Rapid Determination of Water Hardness. I. MUSTEA. Ind. Usoara (Bucharest), **4**:290 ('57). Hardness of industrial feed waters was calcd. from cond.

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measurements performed with help of unbalanced Wheatstone bridge.—*CA*

Determination of the Different Forms of Iron in Natural Waters. YU. S. S. OVCHINNIKOVA. Gidrokhim. Materialy (USSR), **24**:33 ('55). Procedure is given for detn. of ferrous and ferric iron and of colloidal and complexed iron in water. Ferrous iron is detd. colorimetrically with acid solution of α,α'-bipyridyl at pH 4.0, when 0.5 μg of iron can be detd. Ferric iron is detd. colorimetrically with sulfosalicylic acid soln. at pH 4.0. This permits detn. of 1 μg of iron in 10 ml. For detn. of colloidal or complexed iron, sample is boiled with sulfuric acid and potassium permanganate, oxalic acid is added, soln. is neutralized, sodium sulfite is added, and iron is detd. colorimetrically. —*WPA*

Detection of Traces of Iron. F. FEIGL & A. CALDAS. Anal. Chem., **29**:580 ('57). Traces of ferrous and ferric iron can be detected by red color formed in presence of soln. of 2,2'-dipyridine or 1,10-phenanthroline in thioglycolic acid. Procedure is rapid and simple, and reagent is more sensitive than thiocyanate. Examples are given of detection of traces of iron in metallic copper and copper salts, alloys containing cobalt or nickel with copper, metallic tin and manganese, sea water, concd. nitric acid, and various minerals. It is considered that reagent could be used for colorimetric quant. detn. of iron if iron-free thioglycolic acid were used.—*WPA*

The Determination of Nitrate Ions in Water. R. MULLER & O. WIDEMANN. Vom Wasser (Ger.), **22**:247 ('56). Comparison of diphenylamine-H_2SO_4 (**I**), brucine-H_2SO_4 (**II**), Na salicylate (**III**), and phenoldisulfonic acid (**IV**) methods showed latter 2 to be superior for both photometric and visual color comparisons. By means of **IV** nitrates can be detd. with certainty of better than ±0.5 ppm, and by means of **III** with certainty of about ±0.8 ppm in range of 0–10 ppm. **III** is less sensitive to interferences

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by Cl^-, NO_3^-, and Fe. It is, therefore, method of choice. Procedures, reactions, spectra, reaction rates, and concn. effects concerning 4 methods are described.—*CA*

Colorimetric Determination of Nitrate in Water as Orange I. K. R. MIDDLETON. Chem. & Ind. (London), pp. 1147–8 ('57). Method of detn. of NO_3^- by reduction to NO_2^-, which is then used to diazotize sulfanilic acid which is then coupled to form Orange I which is detd. absorptiometrically, is examd. and it is found that reduction is quant. at pH 10.2 by using Zn in presence of Mn. Reagents and procedures are specified.—*CA*

Determination of Oxygen in Liquids. A. D. DE KLERK & B. B. MEURS. Anal. Chim. Acta, **16**:296 ('57). Method has been developed for detn. of oxygen in liquids, based on removal of D.O. by a stream of oxygen-free nitrogen. Mixt. of nitrogen and oxygen then passes through reaction cell which is filled with copper and ammoniacal soln. of ammonium chloride; in this cell, complex cuprous ammonium chloride is formed. When this colorless complex is shaken with air, oxidation occurs and blue cupric ammonium chloride complex is formed. Concn. of cupric complex is measured spectrophotometrically and compared with calibration curve.—*WPA*

The Application of the Permanganate Method for the Determination of Oxygen Which is Dissolved in Water. V. I. VUL'FSON & M. D. ALEKSEEVA. Gidrokhim. Materialy (USSR), **26**:226 ('57). Samples of tap water, 3.5% NaCl soln., distd. H_2O which had stood for prolonged periods of time in contact with air, and H_2O through which O_2 had been bubbled were used to det. O_2 therein according to I_2 method and according to $KMnO_4$ method. In latter, one soln. (H_2O) was mixed with H_2SO_4 and $C_2O_4H_2$ and excess thereof titrated with $KMnO_4$. It was found that accuracy of both methods was same. For anal. of natural waters, $KMnO_4$ method will be cheaper but, in order to apply it correctly, one must then also det. Ca^{++} by same method.—*CA*

Microdetermination of Dissolved Oxygen in Water. I. Nature of the Problem. E. C. POTTER. J. Appl. Chem. (London), 7:285 ('57). Methods available for detn. of low concns. of order of 0.01 ppm of D.O. in H_2O are critically reviewed and methods of assessing their accuracy discussed. Winkler method with an amperometric finish for iodometric titration is recommended with modifications to avoid errors caused by presence of interfering substances in H_2O sample and in reagents used. **II. Design of Water-Sampling Vessels.** P. 297. Errors introduced by use of McLean sampling vessel for detg. D.O. in H_2O up to 0.1 ppm are discussed. New app. is developed by means of which precision of ± 0.0007 ppm in detn. may be obtained. Modification for use with warm H_2O samples is described. **III. Titrimetric Determination of Iodine in Submicrogram Amounts.** E. C. POTTER & J. F. WHITE. P. 309. Sensitive elec. circuit is described for use with all-Pt or W/Pt electrodes in amperometric titration of iodine. Procedure described is sensitive to 0.01 γ of iodine in 100 ml of soln. Presence of up to at least 2 ppm of ferrous, ferric, and cupric ions causes no interference. Thiosulfate and iodate solns. of conc. $10^{-6}N$ can be accurately prepd. by successive diln. of $0.1N$ solns. Titration of 100 ml of $10^{-7}N$ thiosulfate with $10^{-6}N$ iodate is reproducible and practicable. **IV. Test of Winkler's Reaction to Below 0.001 ppm of Dissolved Oxygen.** P. 317. Exptl. test is described of anal. efficiency of Winkler's reaction for detn. of D.O. in H_2O at concns. in range 0.0007–0.0544 mg/l. No bias exceeding 0.0002 mg/l was obtained by using reaction as described; anal. procedure giving precision for single estimate is ± 0.006 mg/l.—*CA*

Colorimetric Determination of the pH in Natural Waters. G. S. KONOVALOV. Gidrokhim. Materialy (USSR), **24**:18 ('55). With colorimetric tubes of 10 ml vol., 7–8 cm high, with small flat bottoms and with side arms for adding solns., pH was detd. within 0.05 in field work by adding indicator to water and comparing colors with buffer solns. prepd. with pH in intervals of 0.1, lengths of all liquid columns being identical. —*CA*

Determination of Radium A and Radium F in Radioactive Spring Waters. T. ISHIMORI & I. HATAYE. Nippon Kagaku Zasshi, **77**:122 ('56). Po can be extracted from its soln. acidified with 3% HNO_3 by using a

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CCl_4 soln. of dithizone. This method is applied to spring water. Ra A (Po^{218}) and Ra F (Po^{210}) in spring waters are extracted by CCl_4 soln. of dithizone and detd. by a Lauritzen electroscope. No. 8 spring of Ikeda Spring, Shimane Prefecture, contained Ra F 0.73×10^{-10}, Ra A 3000×10^{-10}, and Rn 4980×10^{-10} c/l; there is no equil. between Rn and Ra A.—*CA*

Flame Photometry in the Analysis of Natural Waters. I. Sodium Determination. P. Valori & F. Savoini. Ricerca Sci. (Rome), **27**:791 ('57). Procedure for detg. Na by flame photometry is described which is simple and quick in its use, easily reproduced, and can be extended to detn. of other alkali and alk. earth metals. Interferences of some cations, of H_2SO_4, and of HCl were studied and particular mode of diln. combined with addn. of suitable spectrochem. buffer having known high concn. of various constituents is suggested to correct these interferences.—*CA*

The Titrimetric Determination of Sulfate with Lead Nitrate as Titrant and Dithizone as Indicator. E. E. Archer. Analyst (UK), **82**:208 ('57). Method for detn. of sulfate is based on fact that if lead nitrate is added to weakly acid water-acetone soln. contg. sulfate ions, and to which little dithizone has been added, dithizone will not change from its green color to red color of lead dithizonate until excess of lead over sulfate ions is present. Modifications of method, for use in presence of chloride ions and of metals that react with dithizone, are also given.—*WPA*

Complexometric Determination of Sulfate Ions. A. Casini. Ann. Chim. (Rome), **46**:697 ('56). Method for direct volumetric detn. of barium and indirect detn. of sulfate ions is described in which soln. of EDTA (disodium salt) is used, with 1-naphtholphthalein as indicator. Technique appears to be more accurate than previous methods, errors being $\pm 0.1\%$.—*WPA*

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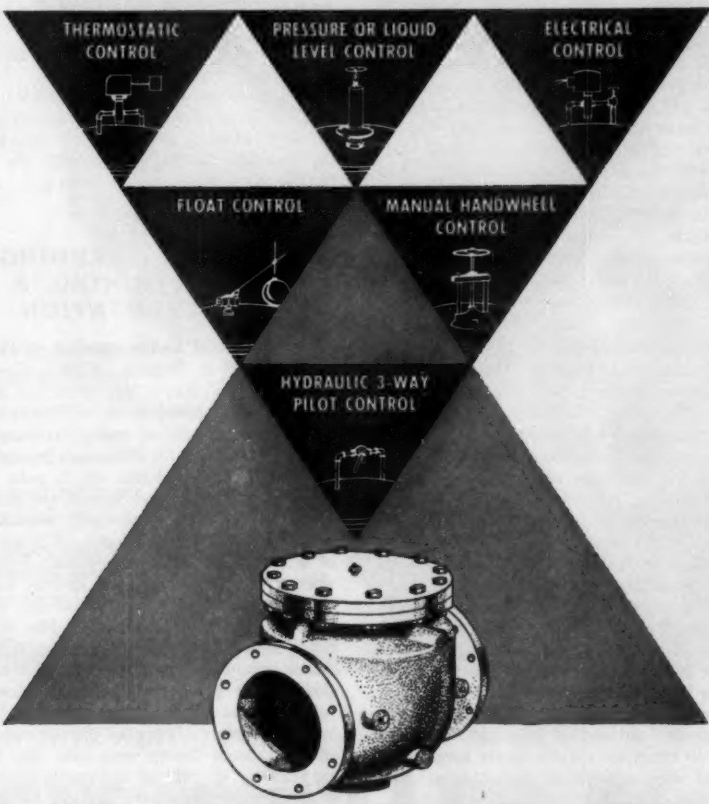

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(*Continued from page 74 P&R*)

Determination of Sulfates in Natural Waters by a Volumetric Method. G. N. NECHIPORENKO. Gidrokhim. Materialy (USSR), **26**:207 ('57). Method is based on following reactions: $MSO_4 + Pb(NO_3)_2$ (I) $= M(NO_3)_2 + PbSO_4$. Excess of **I** is detected by aid of diphenylcarbazole (**II**), which acts as indicator. **II** can only be indicator if it is present in acid form and this will always be case if titration medium is kept at pH 4.0–5.6. Below pH 4.0, **II** will still be in acid form, but at such pH Pb^- (**II**) complex (which has red color) will dissociate and titrations become faulty. After preliminary expts. with pure solns. of $MgSO_4$, Na_2SO_4, and K_2SO_4, and absence or presence of Cl^- or Ca^{++}, method was applied to natural waters, especially to Azov Sea and Volga R., and results are satisfactory—errors rarely exceeding ±2%.—*CA*

Conditions of Storage of Natural Waters for Subsequent Sulfide Determinations. B. A. SKOPINTSEV & A. V. KARPOV. Gidrokhim. Materialy (USSR), **26**:230 ('57). Such natural water should be stored in bottles that contain 7 drops of 40% $Zn(OAc)_2$ soln., bottle must be filled completely (vol. exactly 125 or 200 ml.) and, later on, HS^- can be titrated in presence of H_2SO_4 with I_2—i.e., with mixt. of $KI + KIO_3$ (back titration with $Na_2S_2O_3$). If no O_2 was dissolved simultaneously in H_2O, only 2% of originally present H_2S is lost after 9 hr and 5% after 96 hr. Same method is used for storage of H_2O that contains $H_2S + O_2$; titration is somewhat different, essential difference being that I_2 soln. contains 5% NaCl. By use of special equip. (elongated crucible, bent pipets) devised to keep air from interfering in titration, errors rarely surpass 1%. Method was applied to water from Black Sea.—*CA*

Determination of Volatile Oil in Effluents. J. G. SHERRATT. Analyst (UK), **81**:518 ('56). Need for widely applicable method to detect and det. neutral volatile oils, such as fuel oils, in river waters, sewage, and effluents is discussed, and expts. are described by which method was developed to det. neutral oil present in samples. Method is based on adsorption of oil distd. from sample on activated carbon, elution of oil from carbon, and visual or photometric detn. of turbidity formed when acetone soln. of oil is dild. and sulfuric acid and detergent are added. Tables are given showing recovery of different commercial volatile oils from water, and detn. of volatile oils in various water samples.—*WPA*

Method of Trituration Applied to Water Analysis. E. A. KYUREGYAN. Voprosy Geol i. Gidrogeol. Armyan (USSR), p. 216 ('56). Method of Isakov is applied to dried residues from mineral waters. It is possible to det. Mo 0.0003, Cu 0.0001, Fe oxides 0.0004, Ni 0.0004, and Mn 0.004 g/l. Method can be used in field.—*CA*

CHEMICAL FEEDING, CONDITIONING, & SEDIMENTATION

On the Rate of Sedimentation of Powders in Liquids. R. WOLFF. Kolloid-Z. (Ger.), **150**:71 ('57). Expts. are described on sedimentation of powders in different liquids. Differences in vol. of sediment from a suspended powder with time are dependent on polarity of liquid. Final vol. in polar liquids is less than in nonpolar liquids, but half-value time (period in which half sedimentation height is reached) is greater. Curves of vol. of sediment against time approach hyperbola; numerical eccentricities are greater for polar than for nonpolar liquids. Increase in temp. reduces half-value time and addn. of "sediment-active" substances increases it but reduces final vol. Half-value time is less, the coarser the powder. Grain size alone does not det. final vol. Further investigations are required before theory of phenomena can be evolved; such theory must take into account dependence of rate of sedimentation on viscosity and density.—*WPA*

The Influence of Carbon Dioxide on Aluminoferric Solutions. C. E. HARRIS. Proc. Soc. Wtr. Treat. Exam., **5**:112 ('56). At North Mimms pumping station of Barnet District Water Co., it was observed that satisfactory coagulation with aluminoferric was more easily accomplished by soln. feed than by dry feeder. Expts. on coagulation were made using different sources of water, all contg. much carbonate hardness and carbon dioxide. It was found that considerable

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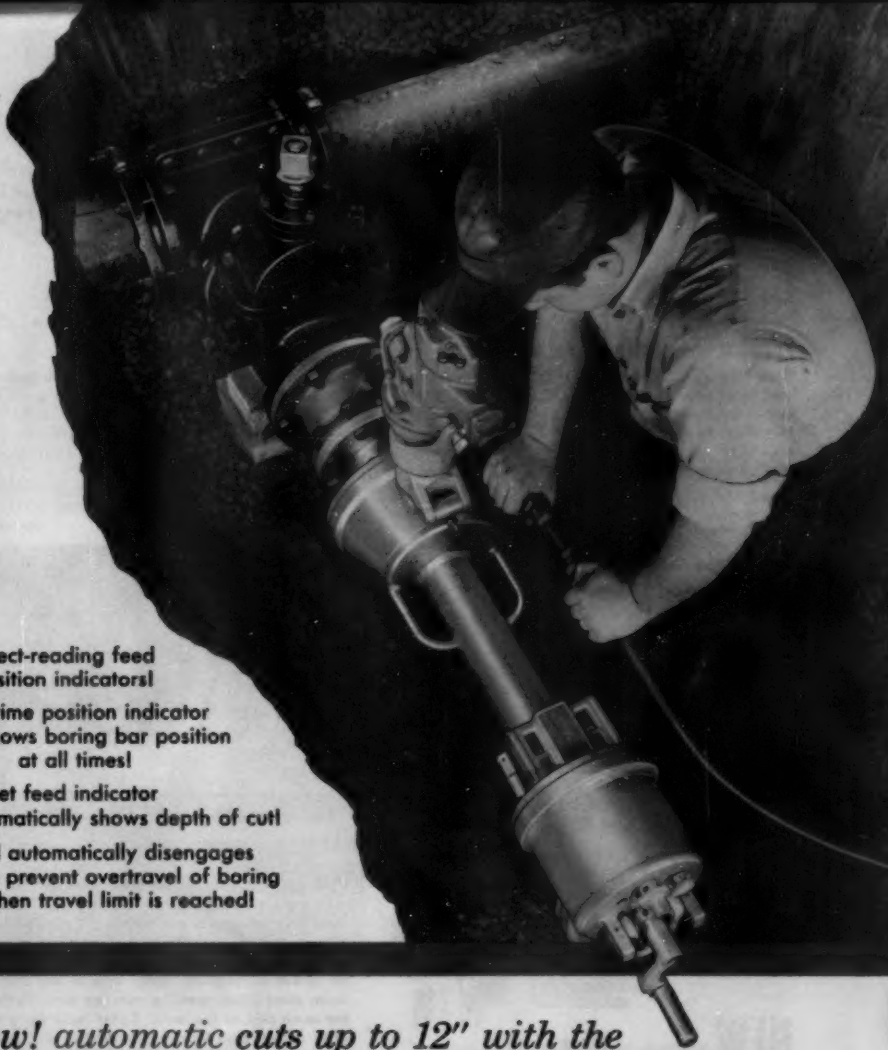

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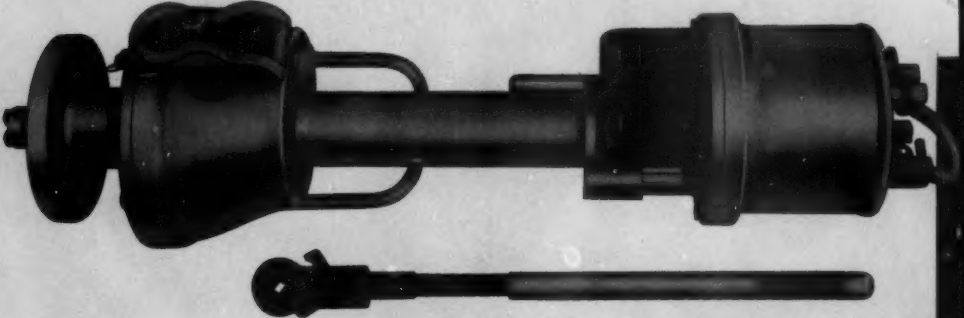

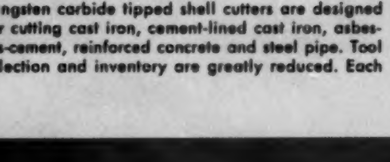

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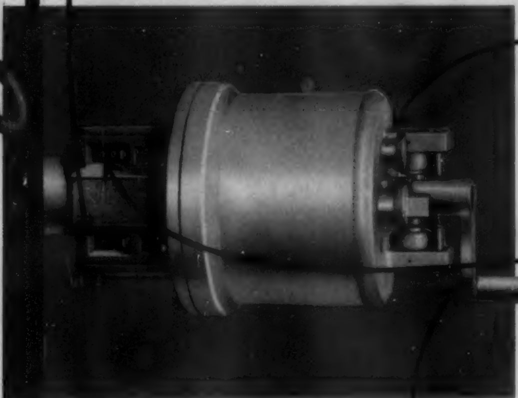

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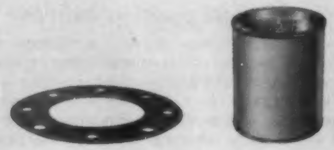

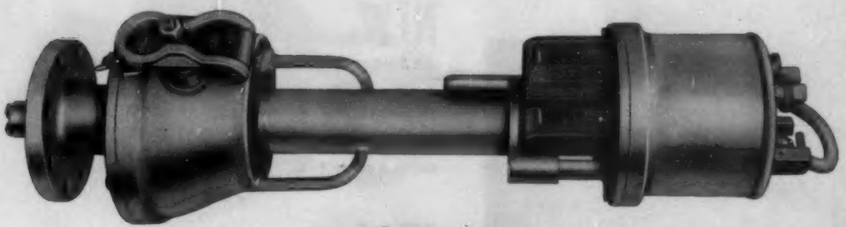

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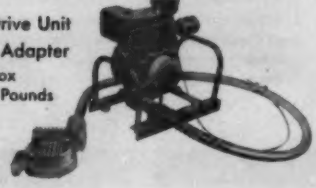

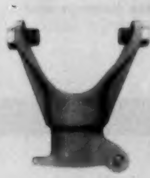

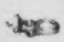

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(Continued from page 76 P&R)

degree of flocculating power is lost when aluminoferric soln. is dild. with hard tap water, as result of retention of carbon dioxide in soln. following release of this gas from carbonate hardness of solvent water. Similar effect is noticed when overdose of coagulant is added to water which is slow to flocculate; during time lag which occurs before flocculation, loss of flocculating power may become most marked. It was found that soln. of aluminoferric of any strength improves as flocculating agent with age, and that, at any age, strong soln. is likely to be a better flocculating agent than weak one. It therefore appears that greater eff. of soln. feed at North Mimms plant is due to ageing time which is automatically afforded by this method.—*WPA*

Electrolytic Dosing of Coagulants. W. S. Holden. Proc. Soc. Wtr. Treat. Exam., **5**:120 ('56). Author describes pilot plant expts. carried out by Coventry Water Undertaking on electrolytic coagulation of water from river Severn. Both aluminium and iron electrodes were used, and it was concluded that the use of iron/iron electrodes would be most economical as regards elec. consumption. Costs of process, and its advantages over conventional coagulation with aluminoferric, are discussed.—*WPA*

Coagulation Experiences at the Sutton Courtenay Water Works. R. H. Burns & G. J. C. Nash. Proc. Soc. Wtr. Treat. Exam., **5**: 91('56). Water supply for Atomic Energy Research Establishment at Harwell is obtained from river Thames and is treated at small water plant at Sutton Courtenay. Water, which is of variable qual. is screened, coagulated and settled in sludge-blanket precipitators, and filtered through rapid gravity filters. Raw water is chlorinated before entering precipitators and treated water is again chlorinated after filtration. When water reaches establishment, distance of 6 mi, it is automatically dechlorinated with sulfur dioxide. Authors describe experiences in initial operation of plant and expts. to find best method of coagulation. Most satisfactory coagulant was found to be chlorinated ferrous sulfate. Softening of water with lime has also been tested and proved satisfactory, and will probably be adopted as permanent method of treatment.—*WPA*

Chlorine-Activated Silica as a Coagulant Acid. G. I. Carver. Proc. Soc. Wtr. Treat. Exam., **5**:102 ('56). About ⅓ of total water supply for Wolverhampton is treated at Cosford, Shropshire, pumping station, where water from river Worfe is treated by prelim. chlorination, coagulation with alum, sedimentation, and rapid gravity filtration. Treated water is mixed with well water and chlorinated before distr. Capac. of plant is 2 mgd but, during winter of 1954, it was necessary to increase flow through plant to 2.5 mgd to meet increased demand. This, together with low winter temp., resulted in deterioration in qual. of treated water, and expts. were therefore carried out on use of chlorine-activated silica as coagulant aid. It was found that use of activated silica improved coagulation considerably and floc passing on to filters formed surface skin which reduced penetration of filters and gave less turbid effluent. However, it also increased loss of head and shortened filter runs considerably. It is thought that, if plant was operated at design capac., load on filters would not shorten filter runs. Improvements in design of sedimentation tanks, in which floc tends to strike baffle and be broken up by it, would improve sedimentation and reduce load on filters. It is also concluded that chlorine is a satisfactory and economical activating agent, provided that chlorine dose required for activation of silica does not greatly exceed that required for normal prelim. chlorination of raw water.—*WPA*

Effect of Purification of Water by the Method of Surface Coagulation. Z. Glinicki, M. Roman, & J. Zakrzewski. Gaz, Woda i Tech. Sanit. (Warsaw), **30**:305 ('56). Purification of water by surface coagulation is as effective as coagulation in bulk or ordinary filtration on rapid filters. —*WPA*

Chlorine Dioxide in the Treatment of Water. K. Schilling. Vom Wasser, **23**: 95 ('56). Author deals with constitution, properties, storage, and handling of chlorine dioxide and with methods of its use in treatment of water and of its detn. Various causes of taste and odor appearing on chlorination of water and experiences in use of chlorine dioxide in USA and in France are described. Bactericidal action of chlorine dioxide is discussed.—*WPA*

(Continued on page 78 P&R)

(*Continued from page 77 P&R*)

FILTRATION

A Novel Rapid Filter for Mechanical Water Purification. K. Griebel. Chemiker-Ztg. (Ger.), **80**:862 ('56). Brassert filter, which is suitable for filtration of process waters for pulp, paper, and textile industries, is described. Filter can remove suspended solids greater than 0.1 mm in diam. and consists of conical revolving drum with many circular openings which hold various filter elements. Operational details are given.—*WPA*

Filter Nozzles for Rapid Filter Plants. P. Brulhart. Vom Wasser (Ger.), **23**:102 ('56). Illustrated article gives acct. of processes of slow and rapid sand filtration in treatment of water, design of rapid sand filtration plants, and new type of filter nozzle suitable for open or closed filtration plants and for ion-exchange plants for softening or removal of salts.—*WPA*

The Choice of a Suitable Runoff System in an Open Contact Filter. D. M. Mintz. Shilist.-Kommunal. Hoshaistvo (USSR), No. 4, p. 17 ('55). Investigations on eff. of backwashing filters were made at number of Russian water works. Difficulties were mainly due to irregular distr. of washing water. Proposals made include use of combined drainage and washing water system and insertion of framework of wooden laths under lowest sand layer.—*WPA*

Experiences With the Rapid Filter System AKH at the Municipal Water Works in Kiev. N. Litvinov. Shilist.-Kommunal. Hoshaistvo (USSR), No. 5, p. 21 ('55). Author reports on operation of rapid filters on AKH system, in which 30% of water enters from above and 70% from below, at Kiev water works. Comparison with normal filters showed that rate of flow could be increased on AKH filters from 6–6.5 m/hr to 12–13 m/hr. In first water treated after regeneration, removal of color and turbidity was reduced; first filtrate should, therefore, be discarded and rate of flow should be reduced for about ½ hr.—*WPA*

Filtration. S. A. Miller. Ind. Eng. Chem., **49**:486 ('57). Literature on new aspects of filtration published during 1956 is reviewed. Subjects discussed include permeability and cake filtration, application of cake eqs., cake washing and dewatering, evaluation of filter media, filter aids, and lab. applications, and use of ultrafilters. A list of 184 references is appended.—*WPA*

Polystyrene Used for Filter Nozzles. Eng. and Contract Record, **68**:14 ('57). Polystyrene nozzles are now fitted to rapid gravity water filters built by Candy Filter Co. Ltd., instead of nozzles made of copper alloy. Advantages of new material include resistance to chem. action by water contg. strong acids or alkalis and great mechanical strength and resistance to erosion, which enable orifices through which air and water are forced during cleaning processes to remain constant in size.—*WPA*

FOREIGN WATER SUPPLIES

New Water Supply System of Buenos Aires. Glenfield Gaz., **31**:2 ('56). Project embarked upon 13 yrs. ago has now developed use of river Plate to increase water supply for Buenos Aires. Water supply system up to 1954 served pop. of 5,000,000 but future total pop. of 6,000,000 is expected. Raw water is treated with aluminium sulfate and pumped to sedimentation tanks, pumping mains having been replaced by system of gravity-feed tunnels. 4 new pumping stations—Caballito, Villa Devoto, Constitución, and Córdoba have been constructed and illustrated description of Caballito pumping station together with details of its operation are given.—*WPA*

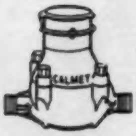
Water Supply of the Middle Rhine Valley Between Bingen and Colenz and Possibilities of Its Extension in the Future. D. Pfeiffer. Bohrtechn.-Brunnenbau (Ger.), **7**:327 ('56). Geology of middle Rhine valley is discussed with reference to water supply and types of central water supply in use are described. Wells in lower and alluvial terraces are most used. For large supplies, wells artificially supplemented with surface water, river water, or impounding reservoirs are recommended.—*WPA*

London's Water Supply—Past, Present and Future. B. W. Grover. Eng. Contract Rec. (London), **69**:98 ('56). Development of water supply for London, Ont., is described. Water is obtained from several

(*Continued on page 80 P&R*)

CALMET
WATER METERS

for



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(*Continued from page 78 P&R*)

groups of wells, providing total supply of 15 mgd. At 2 of well fields, water is aerated before distr., to remove hydrogen sulfide and iron, but remainder of supply requires no treatment other than chlorination. Expts. are in progress on recharge of ground water with river water.—*WPA*

Experiences of the Kiev Water Works in Organizing and Improving the Treatment of Water from the Dnieper. P. N. Podgajevski. Vodosnabzhenie i Sanit. Tekh. (USSR), No. 1, p. 20 ('56). Water supply of town of Kiev is mainly from river Dnieper. Water has considerable degree of color and low but variable turbidity. It is treated by coagulation, sedimentation, and filtration. Because of very low temps. reached, flocculation with aluminium salts is at times unsatisfactory; mixtures of aluminium and iron salts, with proportion of iron varying with temp., are used. Improvements in design of sedimentation tanks and filters are described. Water is chlorinated before and after flocculation. To increase alky. of water when large amts. of aluminium are required for removal of color, milk of lime is added 30 min before water reaches filters. Filtration over marble is suggested as another method.—*WPA*

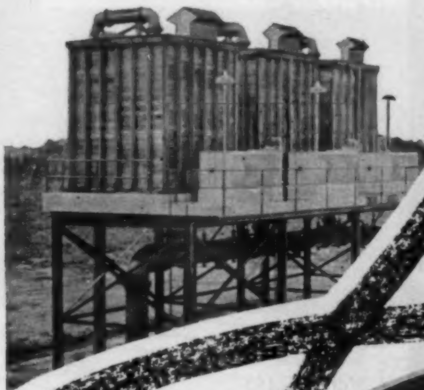
Water Supply Schemes for Kuwait Town. P. H. Perkins. J. Instn. Munic. Engrs., 83:334 ('57). Water supply for Kuwait town, on Persian Gulf, is obtained from boreholes sited about 20 mi from town and from sea-water distn. plant. Both systems were introduced and operated by Kuwait Oil Co. but have now been taken over by Kuwait State Water Dept. Details are given of recent improvements and extensions which include drilling of addl. boreholes and installation of new mains, storage reservoirs, pumping plant, and 2 addl. sea-water distn. plants. Costs, capac. of systems, and estd. water consumption are shown in tables. It is also planned to obtain further supply of 100 mgd from Tigris and Euphrates, just above Basra in Iraq, for domestic and industrial purposes.—*WPA*

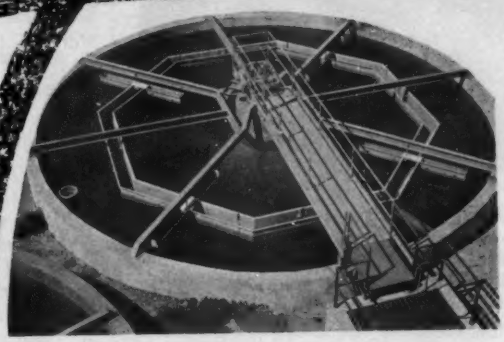
(*Continued on page 82 P&R*)

(*Continued from page 80 P&R*)

Water Supply of Auckland, New Zealand. C. W. Firth. J. Brit. Wtr. Wks. Assn., 39:69 ('57). Water supplies for city of Auckland, New Zealand and neighboring dists. are assured by catchment areas in Waitakere and Hunua-Wharekawa ranges, to west and southeast of city, which can provide estimated 100 mgd. Avg. rainfall, yield from each area, and typical anals. of waters from catchment areas are shown in tables. Supply system at present comprises Waitakere, Nihotupu, Lower Nihotupu, Huia, and Cosseys dams; an intake on Mangatawhiri R.; filtration plants at Swanson, Titirangi and under constr. at Ardmore; and aqueducts and mains to 19 service reservoirs. Author describes topography and geology of catchment areas and gives historical review of city's water supplies.—*WPA*

Water Supply of the Community of Baerum in Norway. T. Stenersen. Gas- u. Wasserfach. (Ger.), 97:933 ('56). Acct. is given of varied types of country and of communities in district of Baerum on inner Oslo Fjord in Norway. Dist., with its center in industrial town of Sandvika, has pop. of about 47,000; increase in pop. has been rapid and further increase to 130,000 is foreseen. After general acct. of water supply requirements and conditions, especially in Norway, author deals with present conditions in Baerum. Water supply is drawn from inland lakes, whose storage capac. has been increased by damming. Water of lakes is acid and yellowish in color, and contains much org. matter. Hygienically and bacteriologically it is not satisfactory supply. Plans for new supply utilizing water courses of Trehörning, Heggeli, and Kampvad, are described. Trehörning water system, in which there is series of 4 lakes, would form central point of supply and water would be piped to it from other systems. Impounding work required and pipe systems are described. Water is similar in compn. to present supply but there is less risk of poln. Treatment works are planned.—*WPA*





Correspondence

Safety Coverage

To the Editor:

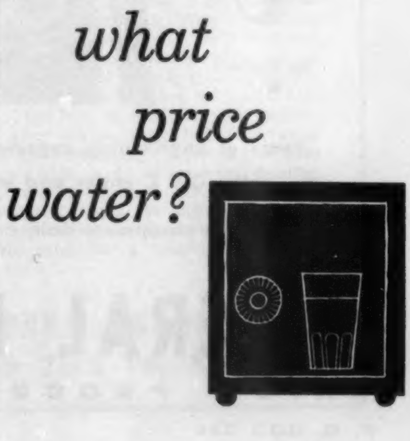
The pictures on your February and March covers are bad examples of how to work safely. Never stand under a boom, especially a loaded one. The man with the spray gun (March cover) runs an excellent chance of being badly hurt either by falling or by being pushed off by hose pressure.

Why advertise bad practices?

BRYANT L. STROTHER

Richmond, Va.
Mar. 24, 1958

Only to prove that it is danger that makes drama, we guess. Anyway, no one can complain about the cover picture on our booklet, "What Price Water?":



Section Meetings

Indiana Section: The regular annual meeting of the Indiana Section was held in Indianapolis at the Sheraton-Lincoln Hotel on Feb. 5–7, 1958. This occasion marked the 50th anniversary of organized water works meetings in Indiana, which began in 1908 with the first meeting of the Indiana Sanitary & Water Supply Assn. In 1925 that organization became the Indiana Section of AWWA. In celebration of the anniversary, many special features were included in the program. A new record of attendance was established, with a total registration of 602, which included 129 ladies.

The program started Wednesday noon with an Old Timers' Luncheon, at which AWWA President-elect Finch presided. "Old time" Section leaders present were introduced, and messages from those not able to attend were read. As a special feature for this luncheon, beautifully designed plaques were presented to all living past chairmen. The afternoon session was devoted to early developments in the water works industry in Indiana and to the history of the association of water works men in Indiana.

The program committee, under the leadership of Leo Louis, arranged a well balanced technical program. The papers were well prepared and well received by large and attentive audiences at each session. Thursday morning's program featured two concurrent sessions: one on administration and the other on water resources and purification. Thursday afternoon's session was a panel discussion on preparation for rate increase and municipal bond issue hearings. [A list of papers and authors will appear in the December 1958 JOURNAL.] Friday morning a breakfast meeting was held, followed by a general forum on a variety of subjects.

The Section was highly honored by having in attendance at this meeting all of the current AWWA officers. In addition, past presidents Weir and LaDue were present, as well as several current and past national directors. Many other guests of both state and national prominence were in attendance.

Chairman Ray Rinehart presided at the business meeting Thursday noon. On this occasion the Section was honored by the presence of Indiana's Governor Harold W. Handley (incidentally, the first state governor to become a member of AWWA). A highlight of the business meeting was the appointment of Secretary Jordan by Governor Handley as a chieftain on his staff with the rank and title of "Sagamore of the Wabash"—an honor similar to the title of Kentucky colonel. During this session tribute was paid to the Membership Committee for its activity, and a gold wristwatch was presented to Robert L. Stookey, who obtained the most new members for 1957—a total of 29. The Joseph F. Bradley Award, based on membership gain and district meeting attendance, was awarded to the Central Area. Certificates were presented to 26 operators who had successfully completed the operators' short course held at Purdue in November. Safety awards were presented to 33 communities. East Chicago and South Bend were named as Indiana's candidates for the national awards.

(*Continued on page 88 P&R*)

Section Meetings

(*Continued from page 86 P&R*)

The following officers were elected at this session: director—John L. Ford Sr., Wabash; chairman—Leo Louis, Gary; vice-chairman—Harvey Wilke, West Lafayette; and secretary-treasurer—Chester H. Canham, Indianapolis.

The number of ladies at the meeting also broke all records, and their programs were well attended. A coffee and rendezvous room was available at all times for their convenience as a headquarters and a place for relaxation. Wednesday afternoon activities featured a tea, followed by a talk on ladies' hats by a professional milliner whose hobby is old and unusual hats. The ladies had a luncheon Thursday noon, with the afternoon devoted to a card party. Prizes were available for each table, and a "handerchief of the month" was presented as a gift to all in attendance.

The "social whirl" reached a climax Thursday evening, when the annual banquet was held. The affair was staged at the famous Indiana Roof Ballroom and was preceded by a cocktail hour. Members of WSWMA were very gracious hosts during this hour and they also provided refreshments during the dance which followed the banquet and entertainment. A total of 567 members and guests attended the banquet and enjoyed a well planned and prepared meal. Floral and other decorations in the ballroom and on tables carried out the golden anniversary theme, and a large birthday cake occupied the spotlight in the center of the ballroom floor. Souvenir menus and ash trays commemorating the anniversary were made available at each table place setting.

Dr. L. E. Burney, surgeon general, US Public Health Service, a native Hoosier and former state health commissioner, was guest of honor and featured speaker at the banquet. Nomination for the Fuller Award went to Jack Gordon, a choice loudly applauded when the announcement was made. Following the banquet, a floor show featuring well known screen, radio, and television performers was presented. The dance which climaxed the evening of festivities provided equal opportunity for ballroom and square dancers.

A 20-page brochure outlining the history of the water works industry in Indiana, as well as the history of the Indiana Section and its predecessor, the Indiana Sanitary & Water Supply Assn., was made available. A really professional job was done by its editors, John E. Kleinhenz and John L. Ford.

The members and guests who enjoyed the special features of this Section meeting are very grateful to the efforts of the Finance Committee that made the gala celebration possible. The meeting left all with the feeling that it was quite successful and that it had been the best ever held.

CHESTER H. CANHAM
Secretary-Treasurer

Kansas Section: The thirteenth annual joint meeting of the Kansas Section and the Kansas Sewage & Industrial Wastes Assn. was held at the Lamer Hotel in Salina Mar. 12–14, 1958. In spite of the inclement weather, the registration was 269, including 41 ladies. After the buffet supper on Wednesday evening, the members and guests were well entertained by the Salina High School Madrigal Choir under the direction of Paul Ryberg. Jack Moranville, of Mississippi Lime Co., performed as master of ceremonies in his usual excellent style. The technical program, prepared by Henry F. Bruner, vice-chairman of the Section and program chairman, was well attended and received in all its sessions. [A list of papers and authors will appear in the December 1958 JOURNAL.]

At the banquet on Thursday evening, 29 water works operator's certificates

(*Continued on page 90 P&R*)

Section Meetings

(Continued from page 88 P&R)

were presented by Howard A. Stoltenberg, secretary of the Certification Examining Board. Next presented were 21 Safety Awards of Merit and one Award of Honor to the representatives of those water departments which had qualified during the past year. Chairman Roy F. Bluejacket presented the Past Chairman's Certificate to B. H. Van Blarcum. A certificate of Life Membership was presented to H. W. Badley. The selection of Paul Dunlap Haney as the Fuller Award nominee from the Section was announced by the committee chairman, Major C. Hagar. Lowell Gish, high school principal of Ottawa, gave a highly entertaining address combining mystery, humor, and serious thought.

At the business meeting following the Friday morning breakfast, these Section officers were elected: chairman—Henry F. Bruner, Kansas City; vice-chairman—O. L. E. Haff, Ottawa; trustee—Howard A. Stoltenberg, Lawrence; secretary-treasurer—H. W. Badley, Salina. The other officers of the Section are Robert H. Hess, director; and John H. Rateuke and Robert J. Schenk, trustees.

Special commendation is due Mrs. Murray A. Wilson and her local entertainment committee for the pleasant program for the visiting wives.

H. W. Badley
Secretary-Treasurer

Montana Section: The Montana Section held its 33rd annual meeting jointly with the Montana Sewage & Industrial Wastes Assn. in Missoula Mar. 20–22, 1958. The registration, one of the largest ever, totaled 154, including 39 ladies.

(Continued on page 92 P&R)

SMITH CUT-IN VALVE AND SLEEVE

The Smith Mechanical Joint Cut-in Valve and Sleeve is truly the answer to the problem of installing gate valves in existing piping which can be relieved of pressure. The design reduces size of excavations, installation time and in-service cost to the minimum. Two substantial stop screws lock the Valve and Sleeve securely in place.

The Cut-in Valve and Sleeve can be installed on any standard class of cast iron pipe. Molded rubber gaskets fit into machined "Stuffing Box Type" joints, which are permanently leak proof. Smith Cut-in Valves are manufactured in compliance with the A.W.W.A. gate valve specification. Write for Bulletin MJ2.

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Section Meetings

(Continued from page 90 P&R)

Among the highlights of the program was a very interesting paper presented by William E. Bullard, of the US Forest Service Div. of Watershed Management, on multiple use of domestic-supply watersheds; he brought out the fact that it is necessary for people to recognize that, in addition to water, there are other products and uses in forested watersheds, especially in the western portions of the United States. Another address, by Stanton Aby, vice-president of Kalman, Inc., Minneapolis, Minn., on municipal bonding, was very interesting and tied in very well with some of the remarks President Merryfield had made regarding municipal financing in his preceding talk on the AWWA public information program.

A tour of a microstrainer installation at the Bonner Mill & Lumber Co., near Missoula, was scheduled, and the group was fortunate in having George R. Evans, vice-president of Glenfield & Kennedy, Inc., on hand to explain the operation of the equipment. The tour also included an inspection of the intake facilities for the Missoula water supply.

At the dinner-dance on Friday evening, the Fuller Award Committee announced that Claiborne W. Brinck, director, Div. of Environmental Sanitation, State Board of Health, Helena, was this year's nominee from the Montana Section.

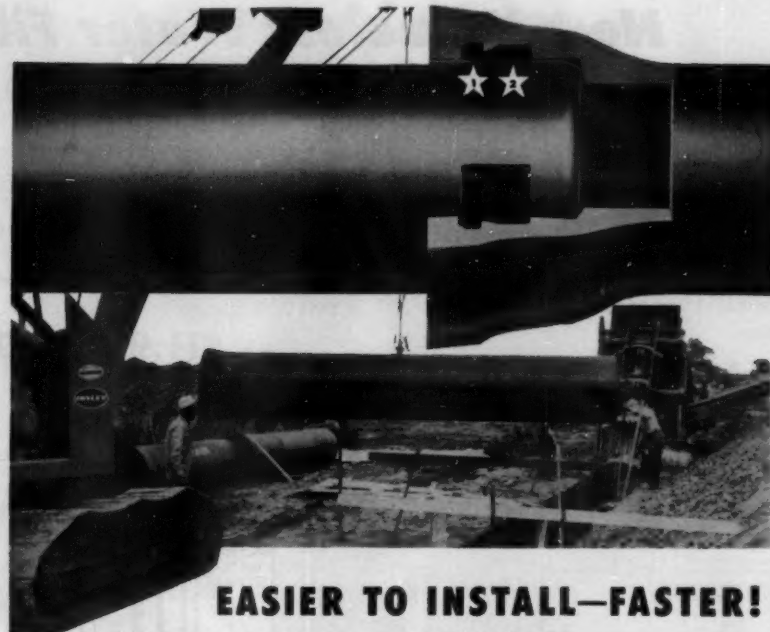
The ladies' program consisted of a visit to the Better Home Show, which was in progress in Missoula during the meeting, and also a luncheon and style show on Friday afternoon.

The Section elected the following officers for the ensuing year: chairman—Carl King, city engineer, Chinook; vice-chairman—Claiborne W. Brinck; trustees—Edward Waldo, manager, Billings Water Dept., and Fred Taylor, superintendent, Butte Water Dept. The current director, Dave S. Thomas, still has 2 years to his term, and A. W. Clarkson was reappointed secretary-treasurer.

The manufacturers' representatives in attendance at the meeting contributed greatly to making it the success that it was.

A. W. Clarkson
Secretary-Treasurer

Montana Section officers: Chairman Carl King (left), Secretary Arthur Clarkson, and Director Dave Thomas.



The Reading Meter

American Civil Engineering Practice. *Robert W. Abbett, ed. John Wiley & Sons, Inc., 440—4th Ave., New York 16, N.Y. (1956–57) 3,255 pp. (3 vols.); Vol. I, $15; Vol. II, $15; Vol. III, $25*

These three volumes present the fundamental principles, procedures, and data of modern civil engineering in concise and usable form, with many illustrations from current practice. The volumes replace Merriman's *American Civil Engineers' Handbook,* which has become obsolete owing to the extraordinary development of new knowledge and new techniques in recent years. Volume I covers metropolitan and community planning, surveying, soil mechanics, foundations, earthwork, tunnels, and allied subjects. Volume II is devoted to the general fields of hydraulic, sanitary, and harbor engineering, while Volume III deals with masonry, reinforced concrete, steel, and timber structures. Each section is written by an authority in that particular specialty. The result is a comprehensive reference source and time saver for professional engineers.

Symposium on pH Measurement. *ASTM Special Technical Publication No. 190, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. (1957) 101 pp.; paperbound; $2.50*

This collection of seven papers was presented at the 59th annual meeting of the ASTM on Jun. 19, 1956. The first and third papers in the publication may interest the average water plant chemist. The first touches on the operational definition of pH and the general application of pH measurements. The preparation and properties of the six National Bureau of Standards pH standards are described, as well as procedures for the standardization of pH assemblies. Attention is also directed to the precautions which contribute to a successful measurement. The third paper discusses the circuits of the more common pH meters available commercially, together with the virtues and limitations of the four principal types of instruments. The remaining papers of the symposium are of a specialized nature, dealing with such matters as the measurement of pH in blood and biological fluids; problems encountered in the presence of high temperatures and pressures; and the determination of acidity in nonaqueous solvents.

The Microbial World. *Roger Y. Stanier, Michael Doudoroff & Edward A. Adelberg. Prentice-Hall, Inc., Englewood Cliffs, N.J. (1957); $8*

The book is divided into three parts. Part I, "The Properties of Microorganisms," explains how microorganisms were discovered, how they are studied, and what they are. Part II, "The Ecology of Microorganisms," describes their distribution in nature, their influence on the living and nonliving environment of the earth's surface, and their exploitation by man for his own ends. Part III, "The Biological Background," provides a brief review of general biological facts and theories. The book includes a selected bibliography with annotations extremely helpful to the student.

(*Continued on page 98 P&R*)

The Reading Meter

(*Continued from page 96 P&R*)

Although this book was written as a school text, it is a very useful addition to the library of a water plant bacteriologist. It does not go into the details of water bacteriology, but it does provide the basic essentials needed for a broader understanding of the subject.

Dictionary of Microbiology. *Morris B. Jacobs, Maurice J. Gerstein & William G. Walter. D. Van Nostrand Co., 120 Alexander St., Princeton, N.J. (1957) 276 pp.; $6.75*

This microbiological dictionary is designed for the needs of many professional fields. It contains more than 5,000 terms, including organisms, tests, culture media, chemical compounds, apparatus, units of measurement, and others. Trying to be all things to all men, the book runs the risk of being nothing to anyone. For example, it defines "filter, membrane" as: "a nitrocellulose disc with uniform porosity in the range of 0.03 to 3 microns used for microbiological filtrations." Such a definition can hardly be considered informative, however accurate it may be. Although the large scope of the book is thus a drawback, it also has an advantage in that someone looking for brief definitions of terms outside his own field might profitably turn to this source before searching in a more intensive, but limited-scope, reference.

Bibliographic Survey of Corrosion, 1952–1953: *A compilation of corrosion abstracts. Pub. 56–11, National Assn. of Corrosion Engineers, 1061 M&M Bldg., Houston 2, Tex. (1956) 382 pp.; $12.50*

This fifth in the NACE series of bibliographies of corrosion literature contains abstracts of 3,344 articles on corrosion and its prevention. The abstracts are arranged topically in accordance with the NACE Filing Index, and author and subject indexes are also included. The series, which now covers the years 1945–53, fur-

(*Continued on page 100 P&R*)

The Reading Meter

(Continued from page 98 P&R)

nishes an invaluable guide to the literature of corrosion.

Estimated Use of Water in the United States, 1955. *Kenneth A. MacKichan. Circular 398, US Geological Survey, Washington 25, D.C. (1957) 18 pp.; paperbound; free*

This report was published in the April 1957 JOURNAL AWWA (pp. 369–91), through the courtesy of the USGS. It is an excellent source of statistical data on water use for various purposes.

Basic Principles of Parliamentary Law and Protocol. *Marguerite Grumme Marguerite Grumme, 3830 Humphrey St., St. Louis 16, Mo. (1955) 68 pp.; paperbound; $1 (discounts on quantities of 6 or more)*

This pocket-size manual, based on *Robert's Rules of Order Revised,* and written by a registered parliamentarian, provides a guide to basic parliamentary law and protocol that should prove invaluable to anyone charged with the conduct of a meeting. In addition to clearly presented summaries of the rules, there is a section on proper procedures and courtesies, as well as a simplified chart of motions and other useful features.

Handbook of Material Trade Names—Supplement II. *O. T. Zimmerman & Irvin Lavine. Industrial Research Service, Inc., Dover, N.H. (1957) 356 pp.; $13.75*

Although only a year has elapsed since Supplement I made its appearance (see Reading Meter, March 1957, p. 90 P&R), thousands of new products have been placed on the market, and many products have been withdrawn. Furthermore, some companies have gone out of business, changed their names, or merged with others. Like its predecessors, this book contains a trade-name section, list-

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The Reading Meter

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ing products alphabetically; a classification section, in which products are grouped by use or composition; and a directory section, giving the addresses of manufacturers and distributors and listing their products. Also included are sections on products withdrawn from the market and on company name and address changes. This series of volumes continues to be an outstanding reference aid to purchasing agents and other wanderers in the forest of trade names, not least harassed technical editors.

Water Unlimited. *Kenneth Roberts. Doubleday & Co., Garden City, N.Y. (1957) 285 pp.; $3.95*

See p. 50 P&R, this issue.

The Fight for Fluoridation. *Donald R. McNeil. Oxford University Press, 114—5th Ave., New York 11, N.Y. (1957) 241 p.; $5*

In the first two chapters of the book, the story of finding the cause of mottled tooth enamel is dramatically told. The description of Dr. Frederick S. McKay's interest and persistence in highlighting the malady and searching for the causative agent is authentic and vivid. There follows the story of the intense and dynamic campaign of the "Wisconsin Group" for statewide fluoridation and for the endorsement of the program by state and national public health, dental, and medical organizations. The reaction to the campaign is told in some detail with typical examples fully related.

Two significant parts of the fluoridation story are, unfortunately, covered very lightly. They are: [1] the establishment of fluoridation at Grand Rapids, the first public supply so treated; and [2] a year-by-year progress report on fluoridation, as shown by the number of people using fluoridated water.

On p. 82 the author states: AWWA "became one of the first national organizations to approve fluoridation. In 1949 they laid down the conditions of approval." This statement is, of course, not accurate (see review of Exner-Waldbott book below).

This is an interesting book. It tries hard to be neutral. Water works men concerned with fluoridation would do well to have a copy available.

The American Fluoridation Experiment. *F. B. Exner & G. L. Waldbott (Introduction and Part 3 by James Rorty, ed.). Devin-Adair Co., 23 E. 26th St., New York 10, N.Y. (1957) 277 pp.; $3.75*

According to its jacket, this book presents "the case against fluoridation by

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The Reading Meter

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two outstanding American physicians." As a considerable body of technical literature on the subject now exists, both in this JOURNAL and elsewhere, no attempt need be made in this review to assess the merits of the technical arguments presented by the authors. Certain other aspects of the book deserve comment, however.

Anyone attempting to make a rational case against fluoridation is confronted with a difficult problem: the preponderance of current opinion in the fields of public health, medicine, and dentistry is in favor of fluoridation, and the statistical evidence available is overwhelmingly on the side of those who claim that fluoridation is of measurable benefit to the general public and without harmful side effects. Antifluoridationists are, therefore, forced to assert: [1] that the statistical data are false or have been misinterpreted; [2] that members of the public health, dental, and medical professions who favor fluoridation either are incompetent in their specialties or are self-seeking, or both; or [3] that regardless of the physiological benefits of fluoridation, it is morally or socially wrong; or some combination of these arguments.

In their book, the authors have made use, either explicitly or implicitly, of all of these alternatives. It is, of course, their right to do so, but it should be stated that they have sometimes used them disingenuously. For example, a footnote on p. 50 supplies the information that Frank J. McClure (one of the principal villains of the piece, along with H. Trendley Dean) holds a Ph.D. degree —apparently with the implication that McClure or someone on his behalf claims a medical or dental doctorate. Again, on p. 126, after quoting a statement made before a conference of state dental directors by F. J. Maier, to the effect that 10–20 per cent fluorosis was not regarded as objectionable, the authors write:

> It is interesting, but perhaps not surprising, that there was no word of protest from the dental directors, and they spent the next two days deciding how they would "put over" fluoridation.

The editor of the book, who is given credit as the author of the Introduction and Part 3, makes much of the fact that the American Water Works Association has not endorsed fluoridation. He is at liberty to draw such comfort as he can from the AWWA policy statement (see 1957 *AWWA Directory*, p. 38), but it is cold comfort. The purveyors of public water supplies, whom AWWA represents, bear an inescapable responsibility for the public health. They do not, however, bear this responsibility by themselves—if they did, their task would be immeasurably more difficult than it is. AWWA regards the medical, dental, and public health professions as fully competent to determine the physiological implications of fluoridation. AWWA likewise regards local governing bodies as fully competent to judge the moral, social, and financial aspects of fluoridation. In its own area of competence—the treatment and distribution of safe, palatable water supplies—AWWA has stated, and reaffirmed on several occasions, its position that the introduction of fluoride within prescribed limits and the maintenance of fluoride concentrations at desired levels is technically feasible.

Like any other treatment process, fluoridation presents its problems, and the deliberations of AWWA will be in the future, as they have been in the past, open to discussions of such problems. Furthermore, AWWA recognizes the right of any of its members to oppose fluoridation on technical or other grounds. But while respecting such views, AWWA equally respects the competence of the public health, dental, and medical professions and their ability to assess the results of their investigations objectively and with the public welfare in mind.

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Blackmail was the charge against Borough Manager Richard Davis of Schuylkill Haven, Pa., last February, when he was brought before the grand jury for an alleged attempt to extort $168.31 from Edwin H. Becker, one of the borough's residents. Actually, the "extortion attempt" on which the action was based had been ordered by the borough council, which instructed its manager to send notice by registered mail to Mr. Becker advising him that his water would be shut off if he continued to refuse payment of his sewer bill. Not blackmail at all; what Mr. Becker should be suing for is alienation of disinfection.

Instant tea will be the next of the "just add water" products if current plans by the Ceylonese are not disrupted by current reactions of their best customers. Reportedly, Britons are most disturbed at this threat to their traditionally leisurely method of brewing their tea. "To try to make Englishmen drink the result of this inhuman chemistry, even if it were as fragrant as the tea drunk in the courts of the Chinese heaven," said the Manchester *Guardian*, "is like asking them to build houses with pipes that do not freeze or to share a warm room with a radiator instead of a chilly one with an open fire. . . ."

Still, if instant tea is to brewed tea as instant coffee is to boiled or percolated coffee, we teatotalers will have to agree that the Red influence in Ceylon must be growing.

(Continued on page 110 P&R)


CASE HISTORY: How Badger PRP* helps communities meet rising costs without raising rates
*Badger Planned Rehabilitation Program

Badger Planned Rehabilitation Program

increases water revenue 39.5%

from meters serviced in "roundup"

Increased revenue? *Really* lost revenue regained! A Midwestern community (name on request) stemmed an annual water revenue loss from old, inaccurate meters — turned it into water department *profits* with modern, accurate Badger meters.

Communities everywhere are joining in the Badger water meter rehabilitation program . . . the systematic replacement of outmoded meters or essential parts that robbed them of revenue.

Is your water department paying its way?

If not, it's time your community held its own water meter roundup — to end water waste from worn-out meters and parts, boost water department revenues, even help meet rising water department operating costs without raising rates. Send for our free booklet, "Take Five," a brief explanation of Badger's Planned Rehabilitation Program. And be sure to ask your Badger representative about our liberal water meter trade-in policy.

What makes the big difference in the meters Badger builds . . .

Exclusive Dovetail Thrust Roller Insert assures accurate registration

Case in point: Old style (A), with full length slot weakens chamber halves, makes them subject to distortion. New style (B) with 77% shorter slot retains original chamber strength and eliminates distortion. Dovetail design prevents shifting of insert but does not impair freedom of disc movement. Just one of many refinements in water meter construction available only with Badger's advanced meter design.

Water is vital

Badger Meters have conserved it better for over 50 years

Badger Water Meters

BADGER METER MFG. CO • 4545 W. Brown Deer Rd. • MILWAUKEE 18, WISCONSIN
OFFICES IN PRINCIPAL CITIES

(Continued from page 106 P&R)

Legal note: ***Landlord's payment obligation.*** The Louisiana state supreme court has ruled that, if a tenant refuses to pay a service charge, the water utility has the right to shut off service from the premises. Payment for water use is the property owner's responsibility, and he—rather than the utility—must accept the risk that a tenant may default. The decision thus upheld a rule of the New Orleans Sewerage & Water Board.

W. P. Bell has been appointed manager of Industries Group sales in the Washington, D.C., office of Allis-Chalmers Mfg. Co., Milwaukee, Wis. He was formerly manager of national defense sales in that office.

Time—and now *Time*—have treated AWWA exprexy Ross Dobbin well. Time, we say, because now, 3 years after his retirement as general manager of the utilities commission at Peterborough, Ont., he continues active in city affairs in the post of alderman. And *Time*, we say, for having picked up one of Ross's typical remarks. We quote the *Time* item in full:

Working committee. In Peterborough, Ont., when the mayor asked an opinion on the ideal size of a group to study a proposed junior college project, Alderman Ross Dobbin volunteered: "Three people—one dead and one out of town."

We haven't heard yet whether Ross got the job!

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ASA president H. Thomas Hallowell Jr. has been reelected to that office for his third consecutive term. The new vice-president is John R. Townsend, special assistant in the Office of Assistant Secretary of Defense (Research & Engineering).

P. B. Mayfield has been named manager of industrial tar products sales by Barrett Div., Allied Chemical & Dye Corp., New York. He has been with Barrett since 1949.

U. A. Fabris has been appointed sales manager for both M. Greenberg's Sons and its subsidiary, Josam Pacific Co. He was formerly assistant sales manager.

M. L. Stuppy has been elected president of F. B. Leopold Co., Zelienople, Pa. He succeeds F. O. Leopold, president for the past 25 years, who will continue active in the firm as chairman of the board. Mr. Stuppy has been vice-president since 1955.

David L. Wright, sales administrator, Badger Meter Mfg. Co., Milwaukee, Wis., is shown being sworn in as adviser to the director of the Water & Sewerage Industry & Utilities Div., Business & Defense Services Administration, US Dept. of Commerce, by BDSA Administrator H. B. McCoy.

NEW MEMBERS

Applications received Mar. 1–31, 1958

Allen, Donavan Jay, Supt., Water & Light & Sewage Dist., Piedmont, S.C. (Apr. '58) *MP*

Bennett, Walter H.; *see* Owosso (Mich.) Water Dept.

Borghard, William G., Project Engr., C. W. Lauman Co., Inc., Box 235, Hicksville, N.Y. (Apr. '58) *RP*

Brooks, Festenia Dewey, Town Mgr., Courtenay St., Pelzer, S.C. (Apr. '58) *D*

Brower, Frank, Water Supt., Union Beach, N.J. (Apr. '58) *MD*

Burt, Edward Mead, Ground Water Geologist, Williams & Works, 238 Ottawa Ave., N.W., Grand Rapids, Mich. (Apr. '58) *R*

Butcher, Thomas L., Supt., Water Dept., 7620 E. Nine Mile Rd., Van Dyke, Mich. (Apr. '58)

Calise, Vincent J., Gen. Sales Mgr., Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y. (Jan. '58)

Carlsbad Munic. Water Dist., Allan O. Kelly, Vice-Pres., Box 265, Carlsbad, Calif. (Corp. M. Apr. '58) *MRPD*

Choppin, Arthur R., Consultant, Kem-Tech Labs., Inc., 949 W. McKinley St., Baton Rouge, La. (Apr. '58)

Clemson Agricultural College, Physical Plant Div., David J. Watson, Director of Physical Plant, Clemson, S.C. (Corp. M. Apr. '58)

Davis, David H., Sales Mgr., Davis Mfg. Co., 321 N. Maple Dr., Beverly Hills, Calif. (Apr. '58) *M*

Eash, C. Harold, Village Mgr., 8820 Brookfield Ave., Brookfield, Ill. (Apr. '58)

Eckert, Louis, III, Sales Engr., Dravo Corp., 54 W. 30th, Indianapolis 8, Ind. (Apr. '58)

Ellis, Roy C., Supt. of Water Softener Plant & Sewage Plant, Junction City, Kan. (Apr. '58) *P*

Emal, Clayton, Light & Water Comr., Minden, Neb. (Apr. '58) *MRPD*

Erback, William, Supt. of Water Dept., Town of Gates, 1548 Buffalo Rd., Rochester 11, N.Y. (Apr. '58) *MD*

Fishel, Vinton C., Dist. Engr., U.S. Geological Survey, Univ. of Kansas, Lawrence, Kan. (Apr. '58)

Frankfort Elec. & Water Plant Bd., Floyd Hahn, Water Supt., 129 W. Main St., Frankfort, Ky. (Munic. Sv. Sub. Apr. '58) *MPD*

Gaeke, G. C., Jr.; *see* Kem-Tech Labs., Inc.

Gannon, John J., State Dept. of Public Health, Bureau of San. Eng., 2323 Sonoma Ave., Santa Rosa, Calif. (Apr. '58)

Ganschow, Elmer, Supt., Water Dept., Springville, N.Y. (Apr. '58)

Gollnick, Eugene E., Dist. Field Engr., Industrial Chemicals, Inc., 2215 S. Main St., South Bend, Ind. (Apr. '58)

Griffith, Edgar C., Civ. Engr., R. W. Robinson, 357 E. 170th St., South Holland, Ill. (Apr. '58) *MRPD*

Hahn, Floyd; *see* Frankfort (Ky.) Elec. & Water Plant Bd.

Hemauer, Alfred F., Mgr., Water Dept., 100 N. 6th Ave., West Bend, Wis. (Apr. '58) *MD*

Hilton, Moy W., Distr. Supt., Water Dept., 3447 Hollins Rd., N.E., Roanoke, Va. (Apr. '58) *D*

Hoffman, William Robert, Service Man, B-I-F Industries, 100 South St., West Lafayette, Ind. (Apr. '58) *P*

Hottinger, Samuel E., Jr., Munic. Engr., Louisiana Rating & Fire Prevention Bureau, Box 730, New Orleans, La. (Apr. '58) *M*

Hutcheson, William W., Chief Operating Engr., Fort Pillow State Farm, Fort Pillow, Tenn. (Apr. '58) *M*

Kelly, Allan O.; *see* Carlsbad (Calif.) Munic. Water Dist.

Kem-Tech Labs., Inc., G. C. Gaeke, Jr., Gen. Mgr., 949 W. McKinley St., Baton Rouge, La. (Corp. M. Apr. '58) *P*

Lane, Bruce S.; *see* The Upjohn Co.

Leland, Richard S., Asst. Supt., Water Dept., 1685 Main St., Santa Monica, Calif. (Apr. '58) *MPD*

Lincoln Park, City of, Louis Palmer, Gen. Foreman, Water Dept., 1355 Southfield Rd., Lincoln Park, Mich. (Munic. Sv. Sub. Apr. '58) *MD*

Maloney, Lester R., Director of Public Works, 10240 Roosevelt Rd., Westchester, Ill. (Apr. '58) *M*

Marlowe, William J., Sales & Service, William E. Pratt Mfg. Foundry, Div. of Joslyn Mfg. & Supply, Joliet, Ill. (Apr. '58)

Massman, R. J.; *see* Milpitas County (Calif.) Water Dist.

McGuire, A. D., Asst. Secy., Kansas Assn. of Munic. Utilities, Box 99, Overland Park, Kan. (Apr. '58)

Miller, Lawson I., 7335 S. Park Ave., Chicago 19, Ill. (Jan. '58)

Milpitas County Water Dist., R. J. Massman, City Engr., City Hall, Milpitas, Calif. (Munic. Sv. Sub. Apr. '58)

Morsy, Ahmad Shawky, Inspector, Villages Services Dept., 22 Giza St., Giza, Egypt (Apr. '58)

North Las Vegas Munic. Water Dept., C. W. Piper, Supt. of Utilities, 1301 E. College Ave., North Las Vegas, Nev. (Munic. Sv. Sub. Apr. '58) *MRD*

Ogle, Arthur J., Water Administrator, Water Dept., Cocoa, Fla. (Apr. '58) *M*

Owosso Water Dept., Walter H. Bennett, Comr. of Public Utilities, Owosso, Mich. (Corp. M. Apr. '58)

Palmer, Louis; *see* City of Lincoln Park (Mich.)

Pickett, Taylor C., Harris County Water Control & Improvement Dist. 22, 8330 Cannon, Houston 21, Tex. (Apr. '58)

Piper, C. W.; *see* North Las Vegas (Nev.) Munic. Water Dept.

Roark, Chris C., Foreman, Neches Butane Products Co., Box 1535, Port Neches, Tex. (Apr. '58)

Robinson, Raleigh W.; *see* Tennessee Div. of Water Resources

Secada, Edward F., Water Service Foreman, Dept. of Public Works, City Hall Annex, Hayward, Calif. (Apr. '58) *D*

Smithen, John K., Director of Public Works, 108 W. Main St., Denison, Tex. (Apr. '58) *MD*

Stein, William J., Asst. Engr., Hazen & Sawyer, 122 E. 42nd St., New York, N.Y. (Apr. '58) *RD*

Switzer, George A., Borough Engr., Dept. of Water Supply, Gas & Elec., Boro Hall, Kew Gardens, N.Y. (Jan. '54)

Tennessee Div. of Water Resources, Raleigh W. Robinson, Water Engr., Cordell Hull Bldg., Nashville, Tenn. (Corp. M. Apr. '58) *R*

Umbenhauer, Elwood J., Supt., Dept. of Water & Sewerage, Box 511, El Paso, Tex. (Oct. '35)

Underwood, Thomas Howard, Gen. Mgr., Utilities Com., Monroe, La. (Apr. '58) *MRP*

Upjohn, The, Co., Bruce S. Lane, Asst. Director of Eng., Kalamazoo, Mich. (Corp. M. Apr. '52)

Van Wormer, Bernard T., City Manager, Empire, Ore. (Apr. '58) *MD*

Watness, Donald H., Chem. Salesman, Jones Chemicals Inc., 2365 Dennis St., Box 2642, Jacksonville, Fla. (Apr. '58)

Watson, David J.; *see* Clemson Agricultural College, Physical Plant Div.

West, Philip W., Consultant, Kem-Tech Labs. Inc., 949 W. McKinley St., Baton Rouge, La. (Apr. '58)

Williams, Melvin W., Chief Engr., Pumping Station, Water Dept., Dubuque, Iowa (Apr. '58) *P*

Williams, W. Albert, Bacteriologist, New York Central Railroad, Selkirk, N.Y. (Apr. '58) *MRPD*

Wischman, Edwin E., Supt., Water Dept., Dunkirk, N.Y. (Apr. '58) *MPD*

Young, Eddy, 210 S. Garrett St., San Angelo, Tex. (Apr. '58)

Zahn, Ellsworth L. E., Water Production Supt., Munic. Bldg., Parson, Kan. (Apr. '58) *MRPD*

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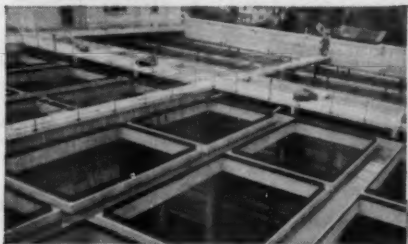
REX Water Treatment Equipment



Better Settling. Use of the Rex Verti-Flo Clarifier makes possible improved settling...increases capacities...effects important cost savings.

Better Flocculation. The Rex Floctrol makes possible the production of an optimum floc with the minimum amount of chemicals ...savings in both power and chemical costs.

Better Mixing. Rex Flash Mixers provide an efficient means of effecting an almost instantaneous dispersion of chemicals throughout the water for better action in the flocculation tanks.

Better Sludge Removal. Rex pioneering in conveyor sludge collector design has led the way to positive, efficient high-capacity removal of sludge from settling tanks...far lower operating and maintenance costs.

Designed for quality...built for performance...

Continuous research and product improvement have long been the guiding principles of CHAIN Belt Company. The important developments illustrated here are but a few of the contributions CHAIN Belt has made toward greater efficiency and economy in the operation of water treatment plants.

A Rex District Sales Engineer will be happy to provide the complete details...or write CHAIN Belt Company, 4609 West Greenfield Avenue, Milwaukee 1, Wis.

CHAIN BELT

Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foster Eng. Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.

Meter Repair Parts:
Meter Specialty Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
F. B. Leopold Co.

Paints:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Alco Products, Inc.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Peerless Pump Div.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sparling Meter Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
Industrial Chemicals, Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.